Low-Level Radioactive Waste Management Plan

Volume II

The Commonwealth of Massachusetts

Low-Level Radioactive Waste Management Board
100 Cambridge Street, Room 903
Boston, MA 02202

Low-Level Radioactive Waste

Management Plan

Volume II

LLRW Management: Responsibilities and Challenges

January 1994

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Publication No. 17515 - 724 - 1600 - 3/94 - 18.78 - C. R.
Approved by: Philmore Anderson III, State Purchasing Agent

printed on recycled paper

Abstract

This volume of the Massachusetts Low-Level Radioactive Waste Management Plan presents a comprehensive discussion of the numerous requirements contained in Massachusetts General Laws c.111H, the Low-Level Radioactive Waste Management Act. Related subjects are included to provide an in-depth review of low-level radioactive waste (LLRW) information and policy options for LLRW management. Also included are recommendations by the Low-Level Radioactive Waste Management Board, the lead agency of the Commonwealth responsible for LLRW management. In addition, various state and federal laws and regulations, as well as an inventory of Massachusetts LLRW generators (and the volumes and activity of LLRW produced and shipped for disposal) are contained in appendices at the end of this volume.

Acknowledgement

The author gratefully acknowledges the contributions and support of the Massachusetts Low-Level Radioactive Waste Management Board and its staff in the review of this Low-Level Radioactive Waste Management Plan.

Notes

Mention of a commercial product or firm in either this volume, or VOLUME I, does not constitute an endorsement by the Low-Level Radioactive Waste Management Board or the Plan's author.

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Abbreviations, Acronyms and Definitions

Above-ground disposal technology: A disposal method using one or more engineered barriers (such as vaults, canisters, casks, walls, or other barriers) above the natural grade of the site.

Abrasive cleaning: The use of abrasive substances to remove contamination from the surface of an object. Such abrasives may include sand or grit used in scouring, and sand used in sand-blasting.

Absorbed dose: The mean energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. The unit of absorbed dose is the rad.

Absorption: Any process in which a liquid is held in the interstices of an absorbent material, such as water being held in a sponge.

Accelerator: A device for imparting kinetic energy to electrically charged particles such as electrons, protons, deuterons, and helium nuclei. Common types of particle accelerators are direct voltage accelerators, cyclotrons, betatrons, and liner accelerators.

Accelerator-produced isotopes: Radioisotopes that are produced in a cyclotron, betatron, or other type of accelerator. These isotopes come under the heading of NARM (Naturally-occurring or Accelerator-produced Radioactive Material).

Access: The federal Low-Level Radioactive Waste Policy Amendments Act of 1985 allowed LLRW generators nationwide access to three disposal facilities (in Barnwell, South Carolina; Beatty, Nevada; and Hanford, Washington) until Dec. 31, 1992. After that date, access to the three disposal sites could be restricted by the regional compact in which each site is located.

Activated hardware: Tools, instruments, equipment, and other metals made radioactive, usually by neutron or other heavy particle irradiation. Activated metals and instruments come from equipment directly associated with reactors, particle accelerators, and some other nuclear devices.

Active maintenance: Any significant activity needed during the period of institutional control to maintain a reasonable assurance that the NRC (or DPH) performance objects are met. The term includes major remedial action, such as replacement of disposal unit barriers, but does not include custodial activities such as repair of fencing, repair or replacement of monitoring equipment, revegetation, minor repair of disposal unit barriers, and general disposal site upkeep such as mowing grass.

Activity: The rate of disintegration (transformation) or decay of radioactive material. The units of activity are the curie (Ci) and the becquerel (Bq).

Acutely hazardous waste: A hazardous waste that has been determined by the Massachusetts Department of Environmental Protection to have more severely hazardous properties than hazardous waste. An acutely hazardous waste is listed in 310 CMR 30.136 (2) and in 310 CMR 30.131 with EPA Hazardous Waste Numbers FO20, FO21, FO22, FO23, FO26, FO27, or FO28.

Adsorption: The adherence of atoms, molecules, or ions of a gas or liquid to the surface of another material. Charcoal filtration of gases and liquids utilizes the adsorption principle.

AEC: The U.S. Atomic Energy Commission.

Affected community: A community, other than a site community, which is identified in an environmental impact report prepared pursuant to section 30 of Chapter 111H, and can be expected to experience significant impacts as a result of the location, development, operation, closure, post-closure observation and maintenance, or institutional control of a facility.

Agreement State: A state that has assumed certain regulatory responsibility over byproduct, source, and small quantities of special nuclear material, by virtue of an agreement with the U.S. Nuclear Regulatory Commission.

Alpha radiation: The least penetrating of the three principal forms of radiation from radioactive materials, alpha radiation will be halted by the outer layer of dead skin cells in human skin, or by a single sheet of paper. However, alpha radiation can damage live body cells if ingested or inhaled through food, water, air, etc.

American Nuclear Insurers: A pool of insurance companies that provides certain types of first party and third party insurance for LLRW disposal facilities.

Appalachian Compact: An interstate compact for the management and disposal of LLRW comprised of Delaware, Maryland, Pennsylvania (host state), and West Virginia.

Aqueous liquid waste: Liquid LLRW composed of radioactive materials dispersed in water. Liquid LLRW must be solidified before shipment to a disposal facility; liquids cannot be accepted for disposal.

As low as reasonably achievable (ALARA): A concept in radiation protection according to which radiation exposures are kept as far below the regulatory limits as possible, taking into account the state of technology achievable and the cost of improvement in relation to: (1) benefit or risk to the environment and to public health and safety; (2) other societal and socioeconomic considerations, and (3) the use of radioactive materials in the public interest in medical diagnosis and therapy, research, the manufacture of consumer products, and the production of electricity by nuclear power reactors.

Atom: The smallest particle of an element that is capable of entering into a chemical reaction. Atoms are electrically neutral. An atom consists of a positively charged nucleus and associated negatively charged electrons.

Atomic Energy Act (AEA): The 1946 federal law that established the U.S. Atomic Energy Commission (AEC) to provide regulatory authority over civilian radioactive materials use. A 1959 amendment to the AEA gave each governor the right to enter into an "agreement" with the AEC to regulate certain types and uses of radioactive materials.

Atomic number: The number of protons in the nucleus of a nuclide. Each chemical element has its own characteristic atomic number. The atomic numbers of the naturally occurring elements range from 1 for hydrogen to 92 for uranium.

Augured hole: See borehole disposal technology.

Background radiation: Radiation that is present in the environment in varying amounts. The sources of this radiation include cosmic radiation, elements in the environment that become radioactive as a result of bombardment by cosmic radiation, and radioactive materials that occur naturally on earth, such as radium, potassium, and uranium.

Bailing: A compaction process in which dry active waste is mechanically bundled and bound for disposal or storage.

Barnwell, South Carolina, disposal site: A site for the disposal of LLRW which, until Dec. 31, 1992, was one of three principal disposal sites used by LLRW generators nationally. The Barnwell site is available for Massachusetts LLRW disposal until June 30, 1994, through a contractual arrangement made between the Low-Level Radioactive Waste Management Board and the Southeast Compact Commission.

Beatty, Nevada: The location of a commercial LLRW disposal site which accepted waste between 1962 until it closed on Dec. 31, 1992.

Becquerel (Bq): In the International System of Units, the becquerel is the unit of measurement of radioactivity equal to one nuclear disintegration per second.

Below-ground disposal technology: A disposal method using one or more engineered barriers (such as vaults, canisters, casks, etc.) and covered by earthen materials below the natural grade of the site.

Below regulatory concern (BRC): A term used to describe a Congressional mandate contained in the federal Low-Level Radioactive Waste Policy Amendments Act of 1985, which directed the NRC to exempt from regulatory requirements certain types and quantities of radioactive material, in order to allow certain wastes with low levels of radioactive contamination to be disposed of as solid waste. Congress reversed this directive in 1992.

Beta radiation: The second most penetrating of the three principal forms of radiation from radioactive materials, beta radiation can penetrate skin and cause damage to living cells. Beta radiation can travel several feet in air, but can be shielded effectively by solid material, such as a one millimeter thickness of aluminum.

Biological waste: Waste that primarily consists of animal carcasses or body parts resulting from medical research. This waste may also include animal bedding and excreta, and culture media labeled with radionuclides; animal or human excreta, animal or human blood or blood parts, or biohazardous substances.

Biosphere: The part of the earth's crust, waters, and atmosphere where living organisms can subsist.

Board (or Management Board): The Massachusetts Low-Level Radioactive Waste Management Board, which is responsible for planning and effecting the management of LLRW in the Commonwealth.

Borehole (or augured hole) disposal technology: A disposal method for below-ground LLRW disposal in which various types of liners (fiberglass, steel, cement, etc.) are inserted into holes bored into the ground, before LLRW packages are lowered into the holes.

Broker: A person engaged in the business of arranging for the collection, transportation, treatment, storage, or disposal of LLRW.

Buffer zone: A parcel of land which is an integral part of a facility that is controlled by the licensee, and acts as a surrounding boundary to the facility.

Byproduct material: Any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material. Byproduct material also refers to the tailings or wastes produced by the extraction or concentration of uranium or thorium from ore processed primarily for its source material content.

Candidate site: A site, identified in accordance with the procedures established in section 20 of Chapter 111H, which will be the subject of detailed site characterization as part of the process to select any

superior site.

Carcinogen: An agent that has the potential to cause cancer.

Cask: A heavily shielded shipping and disposal container for radioactive materials. Lead, steel, and concrete are commonly used in the manufacture of casks.

Central Interstate Compact: An interstate compact for the management and disposal of LLRW comprised of Arkansas, Kansas, Louisiana, Nebraska (host state), and Oklahoma.

Central Midwest Compact: An interstate compact for the management and disposal of LLRW comprised of Illinois (host state) and Kentucky.

Chapter 111H (or M.G.L. c.111H): The Massachusetts law, adopted in 1987, providing the procedures and requirements for the State's management and disposal of LLRW.

Chelating agent: Certain organic compounds capable of forming (multiple) coordinate bonds with metals through two or more atoms of the organic compound, typically resulting in enhanced thermodynamic stability in solution and greatly altered behavior of the metal ions. Examples include amine polycarboxylic acids (e.g., EDTA, DTPA), and polycarboxylic acids (e.g., citric acid, carbolic acid, and glucinic acid). Chelating agents are used to reduce or eliminate metals from radioactively contaminated solutions.

Chem-Nuclear Systems, Inc.: The operator of the Barnwell, South Carolina, LLRW disposal site.

Chemical extraction: The separation of one or more constituents of a mixture of chemicals or chemical compounds by changing the properties of the constituents by some chemical process.

Chief elected official: The mayor of any city; the chairman of the board of selectmen in any town.

Chief executive officer (CEO): The city manager in any city having a city manager; the mayor in any other city; the town manager in any town having a town manager; the chairman of the board of selectmen in any other town.

Class A waste: LLRW characterized by its low concentrations of long-lived radionuclides and concentrations of short-lived radionuclides that will decay to acceptable levels within a 100-year institutional control period, when a disposal facility is maintained after closure. These concentrations cannot exceed 0.1 times the limits in Table 1 or the limits in Column 1 of Table 2. Class A waste need not be segregated from Class B and C wastes if it meets the stability requirements set for Class B and C wastes.

Class B waste: LLRW that contains higher levels of short-lived and long-lived radionuclides than Class A waste. (10 to 40 times higher) In addition to meeting all the minimum requirements for Class A waste, Class B waste must also meet the NRC's minimum stability requirements so that the waste forms or containers can "maintain gross physical properties and identity, over 300 years." [10 CFR 61.7(b)3)] A waste is Class B if its concentration exceeds the value in Column 1 of Table 2, but does not exceed the value in Column 2.

Class C waste: LLRW which, due to its greater concentrations of long-lived or short-lived radionuclides (generally 10 to 100 times higher than Class B waste), must meet more stringent waste form requirements to ensure stability, and must be disposed of in such a way to protect an inadvertent intruder for a longer period of time. These wastes must meet the Class B stability requirements for form or container (300 years) and must be disposed of in a manner which protects against inadvertent intrusion for at least 500 years. A waste is Class C if its concentration is between 0.1 and 1.0 times the value in Table 1, or if

it exceeds the concentrations in Column 2 but does not exceed the value in Column 3 of Table 2.

Table 1	
Radionuclide	Concentration (curies per cubic meter)
C-14	8
C-14 in activated metal	80
Ni-59 in activated metal	220
Nb-94 in activated metal	0.2
Tc-99	3
I-129	0.08
Alpha emitting transuranic nuclides with half-life greater than five years	100*
Pu-241	3,500*
Cm-242	20,000*

* Units are nanocuries per gram.

Table 2			
Radionuclide	Concentration (curies per cubic meter)		
	Column 1	Column 2	Column 3
Total of all nuclides with less than 5-year life time	700	**	**
H-3	40	**	**
Co-60	700	**	**
Ni-63	3.5	70	700
Ni-63 in activated metal	35	700	7,000
Sr-90	0.04	150	7,000
Cs-137	1	44	4,600

** There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other nuclides in Table 2 determine the waste to be Class C independent of these nuclides.

Closure: The permanent termination of LLRW acceptance at a facility, including closure prior to the scheduled closing date, and the implementation of a closure plan.

Coalition of Northeastern Governors (CONEG): An organization comprising the governors of the northeast states which meets to discuss regional problems. In 1983, CONEG representatives from 11 states,

including Massachusetts, prepared a draft regional compact for LLRW disposal. The compact language was not approved by most of the 11 states involved in the negotiations.

Code of Federal Regulations (CFR): A documentation of the general rules by the Executive departments and agencies of the Federal Government. The Code Is divided into 50 titles that represent broad areas subject to Federal regulation. Each title is divided into Chapters that usually bear the name of the Issuing agency. Each Chapter is further subdivided Into Parts covering specific regulatory areas.

Code of Massachusetts Regulations (CMR): A documentation of the general rules by the agencies of the Commonwealth. The Code Is divided into titles, chapters and parts, similar to that of the Code of Federal Regulations.

Commerce Clause: Article 1, Section 8, Clause 3 of the U.S. Constitution provides: "Congress shall have the power...to regulate Commerce...among the several States." The Low-Level Radioactive Waste Policy Amendments Act of 1985 specifically granted Congressionally-approved regional compacts the right to exclude from their disposal sites waste generated in states outside the compact.

Community: A city or town of the Commonwealth.

Community Supervisory Committee: A committee, established pursuant to section 21 of Chapter 111H, to facilitate the participation of a community, in which a candidate site is located, in the activities established In Chapter 111H.

Compact: A legislatively-authorized contract between states. Compacts must be ratified by the Legislatures of the compact states, and by Congress.

Compact commission (or compact committee): The administrative body of a compact, composed of representatives of the member states in the compact.

Compaction: A process using a hydraulic or mechanically driven press which compresses materials Into a smaller volume prior to disposal. Compaction will not reduce the radionuclide content of the waste.

Compatibility: A term used to describe the regulations of an Agreement State as they parallel those of NRC. Some Agreement State rules must be "strictly compatible" or identical to NRC requirements, while other regulations are considered compatible if they meet NRC requirements in "principle."

Compensation: One category of disbursements available to a site community to offset burdens borne by the community.

Comprehensive general liability (CGL) insurance: A type of insurance that covers most Instances of liability to others (third party) for harms caused by the insured.

Comprehensive operating contract: A contract entered Into by an operator and the Management Board pursuant to Chapter 111H, which specifies the community compensation to be provided by the operator or the Board.

Concentration: The amount of a substance in a specified volume. With respect to LLRW, the amount of radionuclides In curies per unit volume of waste.

CONEG: The Coalition of Northeastern Governors.

Containment: The provision of a structure around a source of radiation as a physical barrier to prevent the release or spread of radioactivity.

Contaminated ash: The product of incinerating LLRW that contains some of the products of combustion and most of the radioactivity. This ash can either be wetted and pelletized to eliminate dusting and packaged in a drum, or it can be solidified with cement, asphalt, vinyl ester-styrene, or glass.

Contaminated hardware: Tools, instruments, equipment, and lead or lead shielding having radioactive contamination on their surfaces.

Contamination: Undesired radioactive materials that have been deposited on the surfaces of, or are internally ingrained into structures or equipment, or have been mixed with other materials.

Corrosivity: An aqueous material with a pH less than or equal to 2 or equal to or greater than 12.5; a liquid that corrodes steel at a rate greater than one-quarter inch per year at 130°F.

Cosmic rays: High energy particulates and electromagnetic radiation that originate outside the earth's atmosphere.

Curie: A unit used to measure "radioactivity," or the rate a radioactive substance decays or disintegrates. A curie represents the quantity of material that undergoes 37 billion (3.7×10^{10}) disintegrations per second.

Custodial SAFSTOR: A decommissioning method involving a minimum cleanup and decontamination, followed by a period of safe storage with active protection systems in service, and completed by deferred decontamination. The active protection systems (i.e., principally ventilation) are kept in service, the site is secured against intrusion by physical barriers and by guards, and use of the facility and site is limited to nuclear activities.

Decay: The disintegration of the nucleus of an unstable radionuclide by the spontaneous emission of energy or particles, resulting in a decrease in the number of radioactive atoms in the sample.

Decay chain: The series of nuclides that form sequentially as radioactive decay progresses.

Decommissioning: The safe removal from service of an activity involving radioactive materials or waste, and the reduction of residual radioactivity to a level that permits release of the property for unrestricted use and license termination.

DECON: A decommissioning method in which the equipment, structures, and portions of a facility and site containing radioactive contaminants are removed or decontaminated to a level that permits the property to be released for unrestricted use shortly after cessation of operations.

Decontamination: The removal of radioactive contaminants from surfaces or equipment, using processes such as washing, electropolishing, abrasive cleaning, or cleaning with high pressure water.

Deferred Decontamination: Those actions required after the safe storage period of SAFSTOR to disassemble and remove sufficient radioactive or contaminated materials from the facility and site to permit release of the property for unrestricted use.

Denial of access: The federal Low-Level Radioactive Waste Policy Amendments Act allows compacts that control access to the disposal sites in South Carolina, Nevada, and Washington, to deny states and compacts access to those sites for failing to meet federal timetables for developing new LLRW

disposal facilities. As a result, the compact commission controlling the Nevada site closed it in December, 1992; the compact committee overseeing the Washington site has limited access only to those states in the Washington compact region. The compact commission controlling access to the South Carolina site has allowed access until June 30, 1994, but only to certain states and compact regions which are making "adequate progress" under the federal law. Massachusetts has a contract for access to the Barnwell, South Carolina site, through June 30, 1994.

DEP: The Massachusetts Department of Environmental Protection.

Detailed site characterization: The on-site investigatory and analytical step of site selection established in section 23 of Chapter 111H, and conducted prior to the selection of any superior site.

Determinable property interest: An interest in property created with a special limitation that delimits the duration of the interest.

Development: All activities undertaken with respect to an LLRW facility during the period commencing with the selection of any superior site, and continuing until the commencement of facility operation.

Dewatering: The process of removing water by draining, pumping, or partial evacuation from wet LLRW.

Dismantle: Those actions required to disassemble and/or remove radioactive or contaminated materials from a facility and site.

Disposal: The isolation of LLRW from the biosphere inhabited by human beings and their food chains.

Disposal technologies: The methods which may be employed at a disposal facility for the disposal of LLRW. Examples of disposal technologies include "above-ground vaults," "below-ground vaults," "mined cavity," and "above-ground modular canisters with earthen cover."

Disposal unit: A discrete structure at a disposal site into which LLRW is placed for disposal. Disposal units may include vaults or concrete modules.

DOE: U.S. Department of Energy.

Dose: The quantity of radiation energy absorbed per unit of mass.

Dose equivalent: Expresses the amount of radiation that is absorbed in tissue, accounting for various factors such as type of radiation, expressed in rems. Dose equivalent is the product of absorbed dose multiplied by other factors at the location of interest.

DOT: The U.S. Department of Transportation.

DPH: The Massachusetts Department of Public Health.

Dry active waste (DAW): Waste that commonly consists of paper, cloth, plastics, rubber, tape, non-metal filters, and scrap wood. May also include scrap metal, glass, smoke detectors, electrical conduit and cable, and insulation material. DAW may be both compactible and combustible, compactible and non-combustible, non-compactible but combustible, or non-compactible and non-combustible.

Effective dose equivalent: The sum of the products of the dose equivalent to the organ or tissue and the weighting factors applicable to each of the body organs or tissues that are irradiated.

Electron: A negatively charged particle that orbits an atom's nucleus.

Electropolishing: Any electrochemical process in which radioactive contamination is removed from the surface of a metal object by the removal of small amounts of metal from the metal surface.

Engineered barrier: Any structure or device constructed to increase the ability of a land disposal facility to meet facility performance objectives.

ENTOMB: A decommissioning method in which radioactive contaminants are encased in a structurally long-lived material, such as concrete; the entombed structure is appropriately maintained and continued surveillance is carried out until radioactivity decays to a level permitting unrestricted release of the property.

Envirocare of Utah, Inc.: A privately owned and operated commercial disposal facility in Clive, Utah, for certain types and concentrations of LLRW, mixed, NORM and NARM wastes. The limits in Envirocare's licenses precludes the use of this site for the disposal of all LLRW generated in the country.

Environmental impairment liability (EIL) insurance: A type of third party liability insurance that covers both sudden and non-sudden harm caused by pollution.

Environmental monitoring program: A monitoring program established by the Massachusetts Department of Public Health, after consultation with the Massachusetts Department of Environmental Protection and the Board of Health of each site community, for the purpose of collecting and analyzing environmental data prior to construction and throughout the construction, operation, closure, post-closure observation and maintenance, and institutional control of a facility.

EPA: The U.S. Environmental Protection Agency.

Evaporation: A process where liquid is heated to produce steam which is condensed for reuse. The remaining concentrated waste, or evaporator "concentrates" or "bottoms," is usually solidified for disposal.

Evaporator concentrates (evaporator "bottoms" or "liquors"): The residue produced during the evaporation of liquid wastes. The concentrates may contain boric acid salts or a mixture of sulfate salts, other chemicals and compounds, oils, and metal oxides.

Evapotranspiration: The release of water vapor from plants to the atmosphere.

Exposure: The condition of being made subject to the action of radiation; also frequently the quantity of radiation received. The special unit of exposure is the roentgen.

Exposure pathway: The mechanisms by which radioactive material or waste passes from the source of the material through the environment to an exposed individual.

Facility: A parcel of land, together with the structures, equipment and improvements thereon or appurtenant thereto, which, pursuant to M.G.L. c.111H, is being developed, is used, or has been used for the treatment, storage or disposal of low-level radioactive waste. A "facility" does not include any property used for temporary storage of LLRW in sealed containers by a broker.

Facility license: A license to operate a facility issued by the Massachusetts Department of Public Health pursuant to section 31 of Chapter 111H, or a licensed issued by the U.S. Nuclear Regulatory Commission.

Filtration: A process of removing radioactive particles from fluids by filtering. Filtration media may include cellulosic fibers, diatomaceous earth, activated carbon, etc. Filtration may also be applied to the removal of contamination from gases by using HEPA filters, etc.

Financial risk assessment: A comprehensive evaluation of the potential hazards associated with the operation, closure, post-closure observation and maintenance and institutional control of a storage, treatment or disposal facility, the financial risks associated with these potential hazards, and the financial mechanisms necessary to indemnify or insure against such risks.

Fissile material: Fissionable radioactive material which, in sufficient quantities, is capable of sustaining a nuclear chain reaction. The three primarily fissile materials (fissionable by slow neutrons) are Uranium-233, Uranium-235, and Plutonium-239.

Fission: The splitting of a heavy atomic nucleus into two lighter parts (atomic nuclides of lighter elements), accompanied by the release of a relatively large amount of energy and generally one or more neutrons. Fission can occur spontaneously but is usually caused by nuclear absorption of neutrons or other particles.

Formerly Utilized Sites Remedial Action Program (FUSRAP): A program of the U.S. Department of Energy which identifies and decommissions sites that were once used to support nuclear research activities of no-longer-existing federal agencies, such as the Atomic Energy Commission and the Manhattan Engineering District.

Fuel cycle: The series of steps involved in supplying fuel for nuclear power reactors and handling spent fuel and radioactive waste, including transportation.

Gamma radiation: The greatest penetrating power of the three principal forms of radiation from radioactive materials, gamma radiation can completely penetrate and damage all body organs. Gamma radiation can be shielded effectively by several inches of lead, steel, or concrete, depending upon the shielding material and the energy and intensity of the gamma radiation.

Gamma rays: Short-wave length electromagnetic radiation, which are best stopped or shielded against by dense materials such as concrete, steel, lead or uranium. These rays originate from within the nucleus of the atom.

Gaseous: Describes materials in a vapor or gaseous state, but can include entrained liquids and solids.

Geiger counter: An instrument in which an electronic detection system counts electric pulses that are related to the number of ions produced by ionizing radiation in a gas-filled chamber that is exposed to ionizing radiation. The current is directly proportional to the radiation level.

Generator: A person, including a broker, who produces low-level radioactive waste.

Genetic effects: Health effects of radiation that can be transferred from parents to offspring by inducing change in the genetic material of germ cells.

Go-it-alone (or "unaligned") state: A state that chooses not to join a regional compact for the

purposes of LLRW disposal. A go-it-along state will have to provide for disposal of its LLRW either by developing its own disposal facility, or by contracting with a compact or another unaligned state for access to disposal capacity.

Gray (Gy): In the International System of Units, the unit of absorbed dose. One gray equals 100 rads.

Greater than Class C waste (GTCC): Waste with concentrations of radioactive isotopes that generally make them unacceptable for the types of disposal used for Classes A, B, and C. GTCC wastes continue to be the responsibility of the federal government, not the states. GTCC waste is not included in the Commonwealth's definition of LLRW.

Half-life: The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Each radionuclide has a unique half-life. Measured half-lives vary from millionths of a second to billions of years.

Hanford, Washington, disposal site: A 100-acre tract within the 1000-acre Hanford Reservation, which is leased by the State of Washington from DOE for the disposal of LLRW. The Hanford site is controlled by the Northwest Compact of states.

Hazardous waste: A waste, or combination of wastes, which, because of its quantity, concentration, or physical, chemical or infectious characteristics, may cause, or significantly contribute to an increase in serious irreversible, or incapacitating reversible illness or pose a substantial present or potential hazard to human health, safety, or welfare or to the environment when improperly treated, stored, transported, used or disposed of, or otherwise managed, however, not to include solid or dissolved materials in irrigation return flows or industrial discharges which are point sources subject to permits under section 402 of the Federal Water Pollution Control Act of 1967 as amended, of source, special nuclear, or by-product material as defined by the Atomic Energy Act of 1954.

HEPA filter: A filter used in ventilation and off-gas systems to remove particulate material from the ventilation air stream.

High integrity container (HIC): A container intended to provide structural stability and containment of LLRW for a long period of time, based on the design and the physical and chemical properties of the materials from which they are fabricated. HICs are used for both the transportation and disposal of LLRW.

High-level radioactive waste (HLRW): Intact fuel assemblies that are being discarded after having completed their useful lives in a nuclear reactor (spent fuel) or the portion of the waste generated in the reprocessing of spent fuel that contain virtually all of the fission products separated out during reprocessing.

Host state: A state designated by a compact to host a regional facility for LLRW management.

Hydrogeology: The study of subsurface waters and related geologic aspects of surface waters.

Ignitability: A liquid with a flash point less than 140°F (except aqueous solutions containing less than 24% alcohol); a nonliquid capable of spontaneous and sustained combustion; an ignitable compressed gas pursuant to U.S. Department of Transportation regulations; an oxidizer per DOT regulations.

Impact payments: One category of disbursements to a site community and potentially affected and neighboring communities as well, which provide monies, services or other tangibles over and above the municipality's expenses in having a facility within its borders.

Impermeable: Incapable of being penetrated by solids, liquids, or gases.

Inadvertent intruder: An individual who occupies a facility site after closure and engages in normal activities, such as constructing a home, farming, or other pursuits in which the person might unknowingly be exposed to radiation from LLRW.

Incineration: A process for reducing LLRW volume by burning. Most frequently used for organic liquids, animal carcasses, and most solid institutional wastes.

Ingestion: As used in this Plan, an exposure pathway in which radioactive materials reach the exposed Individual through the Ingestion of food and water.

Inhalation: As used in this Plan, an exposure pathway In which radioactive materials reach the exposed Individual through the breathing process.

Institutional control: The continued observation, monitoring and care of a facility following transfer of the facility license from the operator to the Board.

Interim storage: Storage of low-level radioactive waste for a period of five years or less, or as determined by the licensing agency.

Ion: An atomic particle, atom, or chemical radical bearing an electric charge, either negative or positive.

Ion exchange: A process for selectively removing an ionic constituent from liquid waste by reversibly transferring ions between resins and the waste.

Ion exchange resin: An organic polymer used in an ion exchange column to remove the soluble ions from a solution that is passed over the column. Such columns are commonly used in nuclear power plants to remove radioactive wastes from the circulating cooling water.

Ionization: The process of removing one or more electrons from an atom or molecule, thereby creating an ion.

Ionizing radiation: Any radiation that disassociates electrons from atoms or molecules, thereby producing ions.

Isotopes: Nuclides with the same number of protons but differing numbers of neutrons in the nucleus.

Leachate: Liquid that has percolated through waste or other media and has extracted constituents from dissolved solids or suspended materials.

Lead pig: A lead metal container into which radioactive waste is inserted in order to absorb the radiation. The size of the metal pig depends upon the quantity of radioactive isotopes.

Liability insurance: Provides protection against injury or property damage which may occur to others, known as "third party" liability.

Licensed material: Source material, special nuclear material, or byproduct material received, possessed, used, or transferred under a license issued by the U.S. Nuclear Regulatory Commission or an Agreement State.

Licensee: The users of certain types of radioactive materials in the Commonwealth that are licensed by the U.S. Nuclear Regulatory Commission.

Licensing: Granting permission to receive, possess, use, transfer, or acquire radioactive materials. Facilities for the storage, treatment, and disposal of LLRW would be licensed; companies and institutions using radioactive materials also require licensure.

Liquid scintillation fluid (LSF): Chemical solutions that produce light when bombarded with radiation.

LLW Forum: A national organization of state and compact officials that meets regularly to discuss LLRW management issues.

LLRW: Low-level radioactive waste.

Long-lived isotope: A radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period of time.

Long-term storage: Storage of LLRW for a period of time greater than five years.

Low-level radioactive waste (or "waste") (LLRW): Radioactive material that (1) is neither high-level waste, nor spent nuclear fuel, nor by-product material as defined in section 11(e)(2) of the U.S. Atomic Energy Act of 1954, as amended, 42 U.S. C. s.2014(e); and (2) is classified by the Federal Government as low-level radioactive waste, but not including waste which remains a Federal responsibility, as designated in s.3(b) of the Low-Level Radioactive Waste Policy Act, as amended, 42 U.S.C. s.2021c(b), as in effect as of December 8, 1987.

Low-Level Radioactive Waste Policy Act (LLRWPA): A 1980 federal law that delegated responsibility for LLRW disposal to the states, and authorized the formation of regional compacts among states to manage the disposal of LLRW.

Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA): A 1985 federal law which amended the earlier Act, and established new procedures and milestones for the development of disposal facilities by states and regional compacts.

Low-Level Radioactive Waste Trust Fund: A trust fund established pursuant to Massachusetts General Laws. c.10, section 35H, which shall consist of surcharges collected from users of the LLRW facility in an amount determined by the Management Board on an annual basis.

Low specific activity: Material or waste such as uranium or thorium ores, unirradiated natural or depleted uranium or unirradiated natural thorium, and tritium oxide in aqueous solutions not exceeding 5.0 millicuries concentration per milliliter. It is also waste in which the radioactivity is essentially uniformly distributed throughout, and the estimated average concentrations do not exceed specific millicurie-per-gram limits defined in U.S. Department of Transportation regulations, 49 CFR Part 173.403(n)(4).

Management: The storage, packaging, treatment, transportation, or disposal, where applicable, of LLRW.

Management Act: The State's Low-Level Radioactive Waste Management Act, Massachusetts General Laws c.111H, which became law in December, 1987.

Management Plan (or Plan): The Low-Level Radioactive Waste Management Plan adopted by the

Management Board, after statewide public meetings, to provide for the safe and efficient management of LLRW.

Manifest: The shipping papers that accompany shipments of radioactive materials and LLRW, and provide information on shipping contents, destination, etc.

Massachusetts DEP Hazardous Waste Number: Each hazardous waste that exhibits any of the characteristics specified in 310 CMR 30.120 -30.125 or that is listed in 310 CMR 30.130 - 30.136 has been assigned a Hazardous Waste Number, which is either an EPA Hazardous Waste Number or a Massachusetts Hazardous Waste Number. EPA Hazardous Waste Numbers are assigned to each listed hazardous waste or to each hazardous waste characteristic in 40 CFR 261, as amended. Massachusetts Hazardous Waste Numbers are assigned by the Department of Environmental Protection to additional hazardous wastes listed in 310 CMR 30.130 - 30.136.

Massachusetts Environmental Policy Act (MEPA): The Massachusetts law which lays out a process to ensure an open and deliberative review of all environmental impacts of a potential project, so that decisions may be made, and actions taken, to ensure environmental protection during project development, construction and completion. The MEPA review is conducted by the MEPA office of the Executive Office of Environmental Affairs.

Maxey Flats, Kentucky: The location of a commercial LLRW disposal site which operated between 1963 AND 1977.

Medical isotope generators: Separation columns that generate liquids containing radionuclides such as Technetium-99m or Krypton-81, for use in diagnostic imaging.

M.G.L.: The abbreviation for the "Massachusetts General Laws," which are the laws of the Commonwealth that have been adopted as statutes through the legislative process.

M.G.L. c.111H: The Massachusetts Low-Level Radioactive Waste Management Act.

Microcurie: One millionth of a curie.

Midwest Compact: An interstate compact for the management and disposal of LLRW comprised of Indiana, Iowa, Minnesota, Missouri, Ohio (host state), and Wisconsin. Michigan was removed from membership in 1991.

Migration: Movement of radionuclides from the place where disposed waste was initially emplaced, generally by groundwater transport.

Millicurie: One thousandth of a curie.

Millirem: One thousandth of a rem.

Mined cavity disposal technology: A disposal method using "shaft," "slope," or "drift" mines for LLRW disposal.

Mixed waste: LLRW containing material that is (1) listed as hazardous material in regulations of the Massachusetts Department of Environmental Protection or the U.S. Environmental Protection Agency, or (2) causes the waste to exhibit any of the characteristics (ignitability, corrosivity, reactivity, toxicity) identified in regulations of the DEP or EPA.

Naturally-occurring or Accelerator-produced Radioactive Material (NARM): Radioactive material and waste that is divided into two types: (1) "discrete" material and waste (low volume, high activity accelerator-produced materials, radium needles used in medicine, and drinking water filters from radium-contaminated areas); and (2) "diffuse" material (generally lower activity radium-contaminated soil at locations where radium was used for manufacturing luminous dials and paint or where natural deposits of radium exist, or material in which radium or other naturally-occurring materials have been concentrated). NARM waste is not regulated by the NRC, but is regulated by the Commonwealth.

Naturally-Occurring Radioactive Material (NORM): Radioactive material or waste that has a natural source. It is a subcategory of NARM.

Near-surface disposal facility: As used in this Management Plan, a disposal facility in which waste is placed within the upper 30 meters of the earth's surface.

NGA: The National Governor's Association.

Neighboring community: A community, other than a site community, which according to the most recent decennial census, has at least 20% of its population residing within three miles of any superior site.

NIAT: The Massachusetts Nuclear Incident Advisory Team.

Northeast Compact: An interstate compact for the management and disposal of LLRW comprised of Connecticut and New Jersey. Both states are hosting LLRW facilities for their own state's waste.

Northwest Compact: An interstate compact for the management and disposal of LLRW comprised of Alaska, Hawaii, Idaho, Montana, Oregon, Utah, Washington (host state), and Wyoming.

NRC: U.S. Nuclear Regulatory Commission.

Nuclear energy liability (NEL) insurance: A type of third party liability insurance that covers bodily injury and off-site property damage caused by a "nuclear energy hazard."

Nuclear Incident Advisory Team (NIAT): An arm of the Massachusetts Department of Public Health, the team coordinates emergency response activities, identifies the hazards associated with a transportation event, and determines the necessary response actions.

Nuclear medicine: The branch of medicine that uses radioactive materials for the diagnosis and treatment of disease.

Nuclear power plant: A plant that converts nuclear energy into mechanical, electrical, or other forms of energy.

Nuclear Regulatory Commission (NRC): The federal agency responsible for licensing and regulating commercial uses of radioactive materials. The NRC also assists the U.S. Department of Transportation in regulating the packaging and transportation of radioactive materials and waste.

Nuclear weapons production waste: U.S. Department of Energy waste resulting from research, production, and testing of nuclear defense materials and weapons; naval reactor development and propulsion; and defense waste management. Disposal of this waste is a federal responsibility.

Nuclide: An atomic nucleus that contains a specific number of protons and neutrons. The nuclei of all isotopes of a given element have the same number of protons but different numbers of neutrons, and

therefore are different nuclides.

Occupational dose: The exposure of an individual to radiation as a result of employment, expressed in rems.

Off site: Beyond the boundary of the licensee's property.

On site: Within the boundary of the licensee's property.

Operation: The control, supervision or implementation of the actual physical activities involved in the acceptance, storage, treatment, disposal, or monitoring of LLRW at a facility, and the maintenance of the facility, and any other responsibilities of the operation pertaining to the facility.

Operator: A person designated in accordance with the procedures established in sections 22 and 27 of Chapter 111H to develop and operate an LLRW facility.

Package: A container together with its radioactive contents.

Packaging: The empty container that holds radioactive materials. It may consist of one or more receptacles, absorbent materials, spacing structures, thermal insulation, radiation shielding, service equipment for filling, emptying, venting and pressure relief, and devices for cooling or absorbing mechanical shocks.

Party state: A state that is a member of an LLRW compact.

Passive SAFSTOR: A partial cleanup and decontamination effort initially, followed by a period of safe storage, and completed by deferred decontamination. During the period of safe storage, all systems are deactivated, the structures are secured by strong physical barriers and continuous remote monitoring, and the facility is limited to nuclear use only, while the site may have non-nuclear uses.

Percolation: The movement of water through small openings in a porous material, such as soil or rock.

Performance assessment: A systematic analysis of the potential risks posed by waste management systems and the environment, and a comparison of those risks to established safety requirements.

Performance objectives: Operational requirements that LLRW facilities must meet in order to be licensed.

Person: Any agency or political subdivision of the federal government or the Commonwealth, or of any state, any public or private corporation or authority, individual, firm, joint stock company, partnership, association, trust, estate, institution or other entity, and any officer, employee or agent of such person, and any group of such persons.

Person-rem: The unit of population dose, or the sum of the doses received by all individuals in a population. For example, if 100 people were to receive 5 rem, the population dose would be 500 person-rem.

Picocurie: One trillionth of a curie.

Placarding: Visual warning signs or markings on vehicles shipping certain types and concentrations of radioactive materials.

Possible location: A location, identified in accordance with the statewide screening procedures in Chapter 111H, which will be the subject of preliminary characterization for the purpose of identifying candidate sites.

Post-closure observation and maintenance: The active monitoring and maintenance of a facility which has been closed in preparation for transfer of the facility's license from the operator to the Management Board.

Present value: The amount of money, which if invested at risk-free interest rates today, will compile enough interest so that the sum of the principal plus the accrued interest will equal the required future costs.

Price-Anderson Act: A federal law which provides over $7 billion of financial protection to cover any loss resulting from liability from nuclear power plant accidents. Each nuclear-powered utility company must pay an assessment for its share of any potential loss.

Processor: Any person or company that takes possession of LLRW for purposes of treatment.

Property insurance: Provides coverage for damage to property, such as buildings, equipment, etc.

Property value protection district: An area of land, identified in a Comprehensive Operating Contract executed pursuant to the provisions of Chapter 111H, which includes all land within one-half mile of the waste management area of a facility and may include other land not more than one mile from the waste management area.

Public interest: The common welfare, convenience, benefit, and necessity of the people of the Commonwealth, including public health, safety, and the environment.

Public meeting: A public hearing, satisfying the requirements of Massachusetts General Laws c.30A, section 2, in which an agency presents information, responds to inquires, and hears testimony of interested persons.

Public Participation Coordinator (PPC): The person appointed pursuant to section 6 of Chapter 111H to encourage and facilitate the participation of interested persons in all of the processes established in or pursuant to the Act, and to carry out the other duties prescribed in the Act.

Quality factor: Some types of radiation are more biologically damaging than other types. In expressing the biological damage to exposed individuals, multiplication of the absorbed dose by a quality factor (or factors) provides a common scale for all ionizing radiation.

Rad: A unit of absorbed dose representing the energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest.

Radiation: Alpha particles, beta particles, gamma rays, x-rays, neutrons, high speed electrons, high speed protons, and other particles capable of producing ions. As used in this document, "radiation" does not mean non-ionizing radiation, such as radio or microwaves.

Radiation therapy: Treatment of disease using radioactive materials.

Radioactive material: Any solid, liquid, or gas which emits radiation spontaneously.

Radioactivity: The transformation of unstable atomic nuclei by the emission of radiation.

Radiography: The examination of the structure of materials using a sealed source of radiation.

Radioisotope: An atom having the same number of protons in its nucleus, and thus, the same atomic number as another atom of the same element, but having a different number of neutrons, and therefore, a different mass number, which decays or disintegrates spontaneously, emitting radiation.

Radionuclide: An isotope that eventually undergoes spontaneous disintegration, with the emission of radiation.

Radiopharmaceuticals: Compounds containing radionuclides that are used in nuclear medicine and research.

Radiotoxicity: A term used to denote the relative hazards of various radionuclides or their internal biological effect on living organisms.

Radium waste: Waste that contains radium in the form of radium-contaminated soil, radium needles, or other sources.

RCRA: The federal Resource, Conservation and Recovery Act pertaining to the regulation of hazardous materials and waste.

Reactivity: A waste which is normally unstable and reacts violently without detonating; reacts violently with water; forms an explosive material with water; generates toxic gases, vapors or fumes when mixed with water; contains cyanide or sulfide and generates toxic gases, vapors or fumes at a Ph of between 2 and 12.5; capable of detonation if heated under confinement or at standard temperature and pressure; listed by DOT as a Class A or B explosive.

Recycling: The process of reusing items or materials. Recycling may include some form of treatment before the item or material can be reused for its Intended purpose.

Region: The geographic area comprised of party states to a compact.

Rem: A unit of radiation dose equivalence. The radiation dose equivalent in rems is numerically equal to the absorbed dose in rads multiplied by the quality factor.

Research reactor: A nuclear reactor, often located at a university, used to study atomic structure and to produce radioactive materials for biologic, chemical, and physical Investigations.

Restricted area: An area to which access Is controlled for protection of Individuals from exposure to radiation and radioactive materials.

Retrievability: The ability to recover waste In an Intact container without substantial destruction of the engineered barriers surrounding the waste containers.

Retrieval: The recovery of waste in an Intact container.

Risk: The product of probability and consequence.

Risk assessment: A procedure for determining the risk associated with a given action. Risk assessments often attempt to relate the predicted risk to other common risks.

Safe storage: The period of time starting after the initial decommissioning activities of preparation for safe storage cease in which surveillance and maintenance takes place. The duration of time can vary from a few years to 100 years.

SAFSTOR: The decommissioning alternative in which the nuclear facility is placed (preparation for safe storage), and maintained in a condition that allows the nuclear facility to be safely stored (safe storage), and subsequently decontaminated to levels that permit release for unrestricted use (deferred decontamination).

Scintillation detector or counter: An instrument consisting of a phosphor, photomultiplier tube, and associated electronic circuits that is used to count light emissions produced in the phosphor as a result of exposure to ionizing radiation.

Scintillation liquids: See liquid scintillation fluids.

Scintillation vials: Small plastic or glass vials used to hold scintillation liquids.

Sealed source: Radioactive material that is encased in a capsule designed to prevent leakage or escape of the radioactive material.

Secretary: The Secretary of the Massachusetts Executive Office of Environmental Affairs.

Seismicity: A measure of the likelihood of an area being subject to earthquakes.

Shallow land burial: A land disposal method that relies on the site's natural characteristics as the primary barrier for isolation of the waste. Shallow land burial is a prohibited LLRW disposal technology under Massachusetts law.

Shielding: Materials such as concrete, lead, water, etc., that surround radioactive materials and LLRW to eliminate or reduce the radiation intensity.

Short-lived radionuclides: Radionuclides that decay rapidly.

Shredding: A mechanical process which reduces material size by a cutting action. This process is often used prior to compaction for purposes of volume reduction.

Sievert (Sv): In the International System of Units, the unit of dose equivalent that is equal to 100 rems.

Site community: The community in which is located all or any part of any superior site.

Solidification: A process for transforming liquid or wet wastes into a solid, immobile form before shipment for disposal. Binding materials include concrete, bitumen, vinyl ester-styrene, and glass.

Somatic effects: Health effects of radiation that can damage body tissue.

Source elimination: Eliminating the use of radioactive materials by substituting non-radioactive isotopes for radioactive isotopes.

Source material: Uranium or thorium or any combination of uranium and thorium in any physical or chemical form; or any radioactive material (except special nuclear material) that contains 0.05% or more of uranium, thorium, or any combination of the two.

Source minimization: Minimizing the volume of radioactivity of LLRW prior to its generation by such methods as: (1) avoiding unnecessary contamination of items during the use of radioactive materials; (2) carefully segregating radioactive waste from non-radioactive trash: or (3) substituting non-radioactive isotopes or radioisotopes with shorter half-lives where practicable.

Source term: An inventory of waste characteristics in the total waste stream, over the facility's operating life, and the quantities and forms released from the containment system over time.

Southeast Compact: An interstate compact for the management and disposal of LLRW, comprised of Alabama, Florida, Georgia, Mississippi, North Carolina (next host state), South Carolina (current host state), Tennessee, and Virginia.

Southwestern Compact: An interstate compact for the management and disposal of LLRW, comprised of Arizona, California (host state), North Dakota, and South Dakota.

Special nuclear material: Plutonium, Uranium-233, Uranium-235, or any other material artificially enriched by the foregoing or so designated by the NRC. Special nuclear material does not include source material.

Specific activity: Activity per gram of a given radionuclide in a compound, element, or mixture of materials.

Spent fuel: Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing.

Stabilization: Any process by which radioactive waste is made stable to physical, chemical, or biological degradation. Processes such as solidification, or certain packaging procedures, may result in stabilization.

Storage: The holding of LLRW for treatment or disposal.

Storage for decay (or decay in storage): A procedure in which LLRW with a relatively short half-life is held for natural radioactive decay in compliance with applicable federal and state regulations.

Strippable coating: Any coating that can be painted or layered over a surface which can later be removed, thereby removing radioactive contamination that is adherent to the coating, and leaving a clean surface. Such a coating may be used on the surfaces of tools or other equipment, and on walls and floors in areas of possible contamination.

Subsidence: With regard to LLRW disposal in a near-surface disposal facility, the sinking or collapse of a trench cap or ground surface that could expose waste or contaminated soil, or could alter disposal site performance.

Supercompaction: Compaction of material using a compactor which can apply compressive forces approaching 100 times those achievable by standard compactors, and produce volume reduction ratios approaching eight to one for selected applications. Supercompactible waste streams include those wastes compactible with a standard compactor as well as activated metals, contaminated hardware, and sealed sources.

Superior site: Any site selected by the Management Board, after detailed site characterization, pursuant to section 23 of Chapter 111H.

Superior site CSC: The Community Supervisory Committee for the superior site selected by the Management Board, following detailed site characterization.

Supplier and transporter (S&T) insurance: A type of third party Insurance that covers bodily injury and property damage caused during the shipment of nuclear materials.

Surface contaminated object (SCO): A solid object that is not itself radioactive but which has radioactive material distributed on any of its surfaces.

"Take title:" A provision of the Low-Level Radioactive Waste Policy Amendments Act that required states to take possession of, and assume liability for, LLRW generated within their borders by 1993 or 1996, if they were unable to provide for waste disposal. This portion of the Act was found unconstitutional by the U.S. Supreme Court in June, 1992.

Tectonics: The study of the earth's major structural and deformational features, including their relations, origin, and historic evolution.

Tort: A wrongful act, not Including breach of contract or trust, which results In Injury to another's person, property, reputation or the like, and for which the injured party is entitled to compensation.

Toxic: Having a detrimental effect on humans, plants, or animals; poisonous.

Toxicity: A waste that is likely to leach hazardous concentrations into groundwater, if the waste is Improperly managed. The EPA/DEP-authorized test to ascertain toxicity is the Toxicity Characteristic Leaching Procedure (TCLP) test.

Toxicity Characteristic Leaching Procedure (TCLP) test: A test to determine the "toxicity" of a material or waste, in which the material or waste is exposed to an acidic environment as a means of predicting which materials may be released into groundwater. If materials released exceed levels set by the EPA/DEP, the material or waste is considered legally hazardous, and must be handled as such.

Transportation accident: A transport event ranging from a minor accident to a major collision that involves the vehicle transporting radioactive material or waste, but does not involve a release of radioactive material or waste.

Transportation incident: A transport event involving the release of radioactive material or waste.

Transport index: A number that indicates the level of radiation per hour measured at 3.3 feet (one meter) from the external surface of a package containing material that emits penetrating radiation.

Transuranic: An element with an atomic number greater than 92. All known transuranic elements are radioactive, and are produced artificially.

Transuranic waste: Waste contaminated with alpha-emitting radionuclides with atomic numbers greater than 92, and half-lives greater than 20 years in concentrations greater than 100 nanocuries per gram.

Treatment: Any method, technique, or process, Including source minimization, volume minimization, and storage for decay, designed to change the physical, radioactive, chemical or biological characteristics or composition of LLRW in order to render such waste safer for management, amenable for

recovery, convertible to another usable material, or reduced in volume.

Tritium (H-3): A radioactive isotope of hydrogen, which has one proton and two neutrons. H-3 has a half-life of 12.3 years.

Type A container: A Type A container is packaging designed to withstand normal driving conditions, is strong and durable, and shields handlers from the radioactive elements inside. Type A containers generally take the form of 30 to 55 gallon steel drums with heavy duty closure devices, although there are many other types of Type A containers. All must meet the packaging requirements established in 49 CFR 173, and performance objectives which include free drop, corner drop, puncture, and compression tests.

Type B container: A Type B container must meet all the requirements of a Type A container and some additional standards for hypothetical accident conditions of transportation prescribed in 49 CFR 173. These standards include crash conditions, a 30-foot drop, 1,475 degree heat, puncture and fire tests without significant releases of radioactivity. A Type B container must also safely dissipate heat without any significant increase in surface radiation on the container or the outside of the transport vehicle.

Unaligned (or unaffiliated or "go-it-alone") state: A state that chooses not to join a regional compact for LLRW disposal purposes.

Uniform manifest: Manifest shipping papers that are nationally uniform in their scope and use.

U.S. Ecology, Inc.: The operator of the Hanford, Washington, LLRW disposal site.

U.S.G.S.: The U.S. Geological Survey, a federal agency that provides geologic and hydrologic evaluations relating to LLRW management.

Vitrification: Encapsulating waste in glassy or non-crystalline material.

Volume minimization: Treatment of LLRW after its generation in order to minimize the physical dimensions of the waste and the space required for storage or disposal.

Washing: Any procedure in which tools, glassware, and other contaminated articles are washed in order to partially or completely remove radioactive contamination. Washing may involve the use of detergents or chelating agents.

Waste form: Those physical and chemical characteristics of LLRW of primary importance in influencing its stability in a disposal environment.

Waste management area: That portion of a facility where LLRW has been, is being, or will be treated, stored, or disposed of.

West Valley, New York: The location of a commercial LLRW near-surface disposal facility, which operated from 1963 until it closed in 1975.

Whole body dose: Used in this Management Plan, "whole body dose" should be interpreted to mean "effective dose equivalent." NRC refers to "dose to the whole body" as "any dose to the whole body, gonads, active blood-forming organs, head and trunk, or lens of eye. [10 CFR 20.10(b)(3)] This term is used in many regulations and documents cited in this Plan, and has therefore been retained for consistency. The other term, "effective dose equivalent," represents recent changes in expressing dose.

X-rays: Penetrating electromagnetic radiation with a wave length shorter than that of visible light. These rays are usually produced by exciting the electron field around certain nuclei.

Chapter 1: The Challenges of Effective Low-Level Radioactive Waste Management

1.1 Introduction to VOLUME II

Massachusetts and all other states are required to assume responsibility for the management of low-level radioactive waste (LLRW) generated within their borders. The impetus for state assumption of this obligation was the 1980 Low-Level Radioactive Waste Policy Act, which established the principles for state control of LLRW management and disposal. That law was strengthened in 1985 by "carrot-and-stick" amendments which added timetables for state action and incentives and penalties.[1]

The Commonwealth is assuming this responsibility for another reason, as well. Hundreds of hospitals, universities, and businesses such as biotechnology companies, manufacturers, engineering firms, and nuclear-powered utilities provide products and services that depend upon the use of radioactive materials, and some of these uses produce LLRW. State government has an obligation to ensure the proper and safe management of LLRW, just as it does with regard to household trash, toxic chemical "hazardous" waste, and other categories of waste produced in a modern, industrial society.

The challenges of effective LLRW management demand the dedication and commitment of state and local governments, citizens, and users of radioactive materials that produce LLRW. These challenges are being taken very seriously by State government, because the public's health and safety, and the protection of the environment are at stake.

This document is part of a plan to aid in the development and implementation of short- and long-term LLRW management policy for Massachusetts. VOLUME II synthesizes significant amounts of technical data and public policy discussions into one comprehensive document in order to:

- establish state policy on LLRW management;
- provide the guidance necessary to manage LLRW in a safe and environmentally sound manner;
- address public concerns and information needs; and
- increase public understanding of federally-mandated LLRW management activities.

<u>Statutory Requirement for LLRW Management Plan</u>

This Management Plan is designed to fulfill the requirements of Massachusetts General Laws c.111H (Chapter 111H), the State's Low-Level Radioactive Waste Management Act. Section 12 of Chapter 111H directs the Low-Level Radioactive Waste Management Board (Management Board), as the lead agency

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[1] Both federal laws are included at the end of this volume as Appendices C and D.

responsible for planning and effecting the management of LLRW in the Commonwealth, to:

> "prepare, adopt by regulation, and implement a management plan to provide for the safe and efficient management of low-level radioactive waste. The primary consideration guiding the development of the management plan shall be the protection of public health, safety and the environment."

Management does not just refer to LLRW disposal. Chapter 111H also extends to LLRW storage, packaging, treatment, and transportation as elements of an LLRW management system.

Chapter 111H stipulates a number of elements that the Management Plan must contain. They are designed to provide data about past LLRW management practices, and to ensure informed decisions about future management needs. Table 1-1 summarizes these elements. Chapter 111H in its entirety can be found at the end of this volume, as Appendix A.

A comprehensive discussion of these statutorily-required LLRW management issues is contained in this volume. In addition, related subjects are included to provide an in-depth review of LLRW information and policy options for state and local Massachusetts government leaders, citizens, and radioactive materials users.

The various chapters are designed to stand alone in their treatment of specific aspects of the Plan; taken together, they provide the entire "picture" of LLRW management. The conclusions and recommendations contained within the chapters form the bases for future actions by the Commonwealth, and are incorporated into the "Strategic Options Plan" and "Recommendations" chapters within VOLUME I.

This Management Plan is designed to be a "living document," to be re-examined annually, and amended as necessary to ensure that LLRW produced In Massachusetts is managed In a continually safe and environmentally-protective way.

Questions about the content of VOLUME II or the recommendations contained within it should be addressed to the Low-Level Radioactive Waste Management Board, 100 Cambridge Street, Room 903,

Table 1-1
Required LLRW Management Plan Elements

- A classification system that incorporates radiological, chemical, and biological toxicity, half-life, principal nuclides, radioactivity, chemical reactivity, volume, and other elements to characterize all LLRW generated, stored, treated, or disposed of within MA;
- A review and analysis of existing and new storage, treatment, and disposal technologies and practices, evaluating their:
  - (1) potential public health, safety, and environmental impacts,
  - (2) cost-effectiveness,
  - (3) climatic, geologic, hydrogeologic requirements,
  - (4) suitability for MA, and
  - (5) recommendations to improve these technologies and practices;
- Recommendations to protect property values near any storage, treatment, or disposal facility;
- An Inventory of all LLRW generators in MA;
- An Inventory of all storage, treatment, and disposal facilities in MA;
- A finding of any need for additional storage, treatment, or disposal facilities to handle waste management needs within the next 10 years;
- A review of LLRW transportation routes, practices, regulations and emergency response;
- A report of all LLRW storage, treatment, and disposal facilities that are operating, closed, or temporarily closed;
- An analysis of the adequacy of available insurance protection for LLRW management activities;
- A review of, and recommendations for, a program of source and volume minimization and storage for decay; and
- Interim and emergency storage plans that may have to be implemented if no storage, treatment, or disposal facilities are available.

Source: M.G.L. c.111H. Low-Level Radioactive Waste Management Act. 1987.

Boston, MA. 02202 (telephone [617] 727-6018).

1.2 A Brief History of Low-Level Radioactive Waste Management

Over one million cubic feet of LLRW is disposed of each year in licensed LLRW disposal facilities. Approximately 3-5% of that volume is produced in Massachusetts.

LLRW contains low, but potentially injurious, concentrations of radioactive materials. In general, these wastes have been defined more by what they are not than by what they are. They are not high-level radioactive wastes (HLRW) or spent fuel wastes. Most LLRW emits no detectable heat, and requires little or no shielding to protect handlers from exceeding established exposure levels. The majority of these wastes lose most of their radioactivity in a few months; some, however, will take from several hundreds to thousands of years to decay to levels of activity equivalent to those found in everyday, non-radioactive materials and objects.

LLRW includes paper trash, filters, plastic, glassware, protective clothing, discarded tools and equipment, wet sludges, solidified resins, and organic liquids that have been contaminated with or otherwise contain small amounts of radioactivity. Chapter 4 contains a detailed description of this waste, the categories of companies, hospitals, universities, and power plants that generate it, and why it is produced in Massachusetts. Appendix F at the end of this volume contains an inventory of Massachusetts radioactive materials users, for the year 1992.

Federal Management

Public concern over the production of LLRW began after the United States government initiated its nuclear weapons testing and development programs in the 1940s, and established shallow-land burial sites on government-owned lands for the disposal of federally-produced LLRW. Currently operated by the U.S. Department of Energy (DOE), these sites are situated at 14 locations around the country, as shown in Figure 1-A.

In addition to managing LLRW by land disposal, the federal government also permitted ocean disposal. Small quantities of LLRW were deposited in 10 locations in both the Atlantic and Pacific oceans until this method was halted in 1970. The ocean disposal sites are also shown in Figure 1-A.

One of these ocean disposal sites was located about 20 miles offshore in Massachusetts Bay, where approximately 4,000 containers are thought to have been dumped between 1952 and 1959. The undecayed radioactive content of those containers was 2,400 curies[2] at the time of burial, according to a report prepared for DOE.[3] No estimates are available concerning the amount of radioactivity, if any, that remains at that site. In December, 1991, a survey of a portion of the site was conducted using "sidescan sonar" technology to determine the distribution of apparent man-made objects. The sonar results identified such objects as mounds of dredged materials, lobster trap lines, shipwrecks, schools of fish, "probable" barrels,

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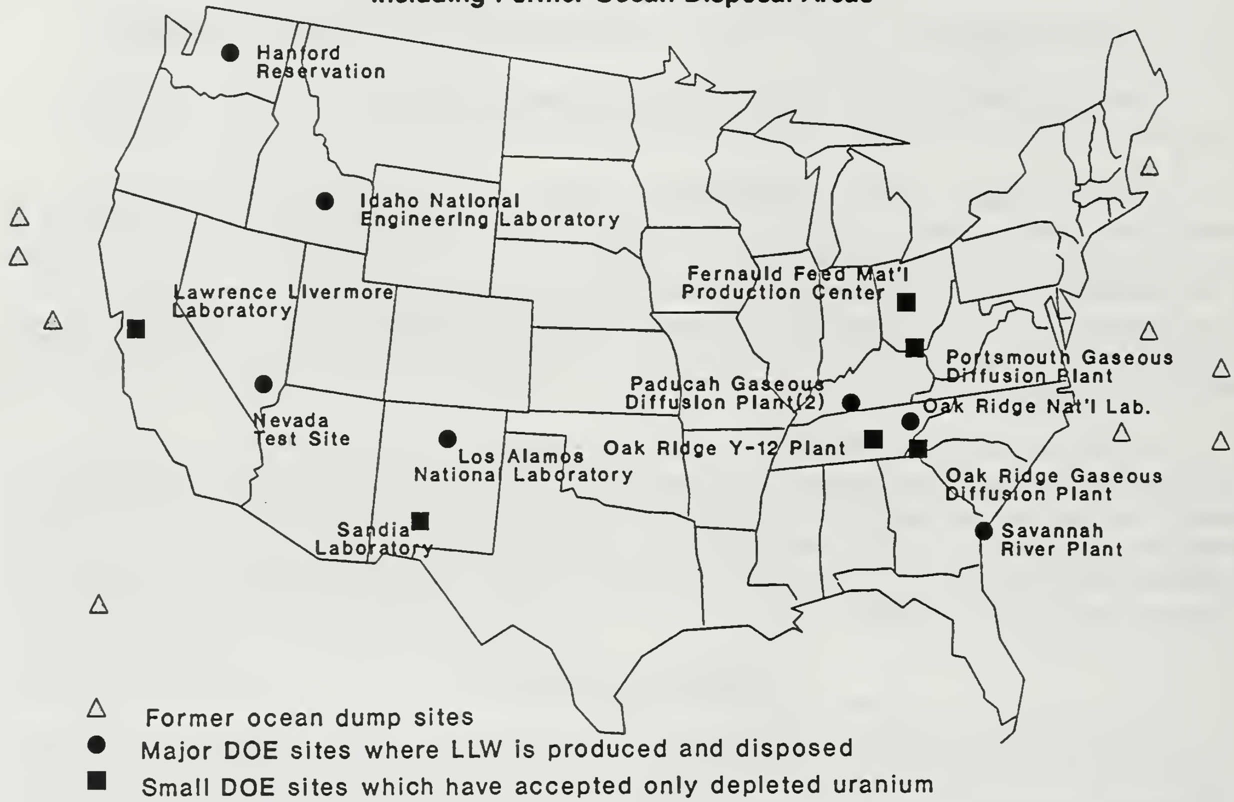
[2] A "curie" is a unit used to measure "activity," i.e., the rate of disintegration (transformation) or decay of radioactive material. A curie represents the quantity of material that undergoes 37 billion (3.7×10^{10}) disintegrations per second.

[3] U.S. Department of Energy. Integrated Data Base for 1987: Spent Fuel and Radioactive Waste Inventories, Projections and Characteristics. DOE/RW-0006, Rev. 3, Oak Ridge, TN, September, 1987.

Figure 1-A
Locations of U.S. Department of Energy LLRW Disposal Sites, including Former Ocean Disposal Areas



and "unknown targets," which could also have been LLRW barrels. A second survey was conducted in May and June, 1992, and involved the collection of samples of ocean sediment, fish, and shellfish, which were analyzed for various chemical and radionuclide content. Radioactivity was found in one sample collected; fish and shellfish samples did not indicate any measurable radioactivity, according to the Environmental Protection Agency (EPA), the federal agency overseeing the investigation of possible radiological contamination In Boston Harbor.

In 1946, Congress passed the Atomic Energy Act (AEA), which assigned to the federal government regulatory authority over radioactive waste. As uses of radioactive materials expanded from defense-related activities to the commercial sector, the AEA was amended to transfer some responsibility to the states. A 1959 amendment gave each governor the right to enter into an "agreement" with the Atomic Energy Commission (AEC) to regulate certain types and quantities of radioactive materials. Currently, 29 states participate In this Agreement State program. Massachusetts is not presently a participant, but is actively pursuing the requirements necessary to become an Agreement State.[4]

Non-Government Radioactive Waste

Non-government waste was first produced in the early 1950s by nuclear-powered electric generating

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[4] Additional details about the Agreement State program are contained in Chapter 2 of this volume.

plants and research and treatment activities for cancer and other diseases. During this period, LLRW was disposed of either at DOE sites, or at sea. As the need for waste disposal increased, the AEC decided in 1960 that non-government commercial waste could no longer be disposed of in the federal disposal sites.

As a result of this decision, six sites were established for the disposal of non-government waste. The first opened in Beatty, Nevada, in 1962. Between that year and 1971, additional sites opened in Barnwell, South Carolina; Hanford, Washington; Maxey Flats, Kentucky; Sheffield, Illinois; and West Valley, New York. Table 1-2 shows the waste volumes and radioactivity disposed of in each site from the year they opened through 1992.

Table 1-2
Waste Volume and Radioactivity at Six Commercial Disposal Sites

Site	Site Opened	Site Closed	Total Waste Volume (cubic feet)	Total Radioactivity (curies)[a]
Beatty, NV	1962	December 31, 1992	4,853,619[b]	641,119[b]
Maxey Flats, KY	1963	1977	4,776,836	2,400,690
West Valley, NY	1963	1975	2,467,161	1,262,300
Hanford, WA	1965	—[c]	12,350,194[b]	2,334,078[b]
Sheffield, IL	1965	1978	3,119,138	60,206
Barnwell, SC	1971	—[d]	24,160,006[b]	6,517,355[b]

[a] The values represent radioactivity at time of disposal; current radioactivity is less as a result of radioactive decay.
[b] Data through 1992.
[c] The disposal site at Hanford, Washington, will continue to accept LLRW from states in the Northwest and Rocky Mountain Compact regions, only.
[d] The Barnwell, South Carolina site is expected to remain open to certain out-of-state generators through June 30, 1994, and to in-region generators, through 1995. The company that operates the site is seeking to make the site available beyond those dates.

Source: U.S. Department of Energy

Each of the six commercial disposal sites listed in Table 1-2 used the shallow-land burial method of disposal. In such disposal, the waste containers are placed in trenches dug out of the ground about 30 feet below the surface. The trenches are engineered to utilize drainage and monitoring systems. As the disposal containers fill the trenches, spaces between the containers are filled with sand, dirt, or other material, and the trenches are covered with earth to reduce surface radiation exposure and water infiltration.

Between 1975 and 1978, three of the six sites closed. The Sheffield, Illinois, burial ground had reached maximum capacity by 1978. During an evaluation of the site operator's petition to expand the number of trenches, radioactive contamination was discovered to have migrated out of the trenches and into the groundwater. The U.S. Nuclear Regulatory Commission (NRC) prohibited using the desired area for new trenches, due to the abundance of permeable soil, and the site subsequently closed down. The closure of the New York and Kentucky sites was due to problems of water accumulating in the disposal trenches.

The physical form of the waste sent for disposal was a major contributor to the closing of the three sites. No policy existed on waste minimization, and cardboard and fiberboard packages were allowed as packaging, even though they could easily deteriorate. Some waste packages contained air spaces that caused the waste to settle, leading to settling or slumping of the earthen trench cover which, in turn, enabled rain water to gather and percolate down to the wastes. In addition, some LLRW was combined with toxic

chemical waste that further accelerated package degradation, and allowed radioactive materials to leach out.

The manner in which the wastes were placed into the trenches also led to problems. Water was allowed to accumulate in open trenches while they were being filled, and waste was not separated according to its characteristics. For example, wastes containing toxic chemicals were not kept separate from other wastes. Thus, both the characteristics of the waste accepted for disposal, and the management procedures used at the sites, encouraged faster settling and waste degradation.

The operations and problems of all six sites are summarized in Appendix 1A at the end of this chapter.[5]

Lessons in waste disposal management have been learned from the experiences of the early sites, and especially from the problems at the three sites that were closed. A recent DOE report makes the following comment:

> "Experience at these [three] sites indicates that a combination of unstable waste forms, specific site characteristics, and certain design and operational practices led to problems with water management and site instability. There were also problems with respect to financial assurance and institutional control of the sites."[6]

In addition, lessons learned at these problem sites have led to the development of improved technology for safer LLRW disposal.

1.3 The Passage of Federal Laws

The experiences of both the closed and open commercial LLRW disposal facilities led to the passage of the Low-Level Radioactive Waste Policy Act In 1980 and the development of federal standards for siting and licensing LLRW disposal facilities [10 CFR Part 61]. The governors of the three sited states that remained open in the late 1970s (Nevada, South Carolina and Washington) were under continuous public pressure over the operation of the near surface disposal burial sites. Citizens of those states did not want their states to serve as national depositories for LLRW, not only because of the potential for environmental and health problems from accidents at the disposal facilities, but also because of concerns over the safety of waste transportation.

During 1979, routine inspections at all three sites revealed a pattern of transportation and packaging violations, compelling the three states' governors to sign a tri-state agreement requesting the NRC and the U.S. Department of Transportation (DOT) to enforce waste packaging and transportation regulations, and demanding new plans for LLRW disposal by August 1, 1979. The tri-state agreement, which was implemented by Executive Orders in each of the three states, required LLRW generators to certify that state and federal packaging, transportation, and disposal standards had been met.

Despite assurances from the NRC and DOT, violations continued to occur. For example, a 1979

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[5] A seventh LLRW disposal site has been operating in the U.S. since 1988, and accepts limited types and concentrations of LLRW. This site continues in operation, and is also described in Appendix 1A.

[6] U.S. Department of Energy. Directions in Low-Level Radioactive Waste Management. DOE/LLW-103, 1990.

shipment of cobalt-contaminated LLRW arrived at Hanford, Washington, improperly packaged and leaking radioactively contaminated water. The burial facility had to be closed temporarily for clean-up, and certain members of the public became involved in fighting to keep the site closed permanently. When the U.S. Geological Survey (USGS) discovered LLRW buried outside the site disposal fence at the Beatty, Nevada site, Nevada Governor Robert List closed that site on Oct. 23, 1979, until improved record-keeping and quality assurance measures were Implemented.

For a time in 1979, the Barnwell, South Carolina, site was the only one in the nation available to the generators of LLRW. But South Carolina began down-sizing waste receipts, from 2.4 million cubic feet per year in 1978 to 1.2 million cubic feet in 1981. In addition, South Carolina Imposed restrictions on the type of waste it would accept -- disallowing certain organic chemical wastes produced by hospitals, medical research companies, and universities. This policy caused a national disposal crisis, and some hospital officials prepared to shut down their cancer treatment operations for lack of facilities for medical waste disposal.

The 1980 Federal Act

The emergency ended when the Hanford, Washington, facility reopened. The experience, however, raised the public's awareness, and spurred into action several committees of the U.S. House of Representatives. Congress held hearings to evaluate the potential of making commercial LLRW disposal a federal responsibility. In November, 1980, citizens from the State of Washington approved an Initiative petition that would have kept the Hanford site open only to wastes produced in Washington, and to medical wastes generated throughout the country after July 1, 1981.

The Washington initiative law was later ruled unconstitutional by a U.S. Court of Appeals,[7] but the voters' message had been heard, even before the initiative became law. Washington Governor Dixie Lee Ray joined Governor List and South Carolina Governor Richard Riley in declaring their unwillingness to continue bearing the burden of disposing LLRW from the entire country.

Responding to this situation, Senator Strom Thurmond of South Carolina proposed an amendment on LLRW disposal to Senate 2189, the high-level radioactive waste disposal bill then pending in the U.S. Senate. The Thurmond amendment was designed to authorize and encourage states to enter into Interstate compacts for LLRW disposal, and to give duly-authorized compacts the authority to exclude waste from outside the compact regions. At the same time, Congressman Butler Derrick of South Carolina attached a similar amendment to a high-level waste bill In the House of Representatives.

In December, 1980, Congress was still unable to agree on the high-level waste disposal portions of the legislation, but its members did agree on the LLRW sections. These portions of the bill were separated, and finally enacted as the Low-Level Radioactive Waste Policy Act of 1980 (LLRWPA), Public Law 96-573.

The LLRWPA declared that each state Is responsible to provide for disposal capacity, either Inside or outside the state's boundaries, for all LLRW generated within the state, except for wastes resulting from certaln defense activities. The law also stated Congress' belief that "low-level radioactive waste can be most safely and efficiently managed on a regional basis," and encouraged states to establish regional agreements, or "compacts" of states, to site and operate regional disposal facilities.

The 1980 law provided a real incentive to encourage states to regionalize: it allowed regional compacts to exclude waste from outside the region after Jan. 1, 1986.

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[7] Ninth Circuit Court of Appeals. Washington State Building and Construction Trades Council, AFC-CIO v. Spellman. 684 Federal Reporter 2d 627, 1992.

<u>The 1985 Amendments Act</u>

By 1984, the LLRWPA appeared to be moving states forward in making decisions about LLRW disposal. Legislatures in 37 states had adopted legislation to join seven compacts, and the compact legislation had been submitted to Congress for ratification. Among the seven were three compacts that included the existing "sited states" (South Carolina, Nevada and Washington). Under the LLRWPA, approval of the compacts by Congress would allow these compact states to limit access to the existing three sites, as of Jan. 1, 1986.

Because of the complexity of negotiating the details of host and party state responsibilities, and other complicated compact issues, it became clear that the newly proposed regional compacts would not be able to establish disposal sites by the Jan. 1, 1986, deadline. As these new compacts were considered for Congressional approval, Congressmen and Senators representing independent states and states in compact regions that did not have access to a disposal site refused to allow the compacts containing the three sited states to pass Congress without assurances that their states would continue to have access to disposal facilities beyond the 1986 date. Negotiations to break the deadlock between these opposing forces began in October, 1984, when the Chairman of the House Committee on Interior and Insular Affairs, Morris Udall of Arizona (a non-compact, non-sited state), proposed legislation amending the 1980 Act.

Congressman Udall's legislation prompted states and compacts to organize through the National Governors' Association (NGA), to develop acceptable compromise legislation, which was approved by Congress in December, 1985. The new law, the Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPAA), Public Law 99-240, included mandatory deadlines to force states and regions without disposal sites to build new facilities, and both incentives and penalties to help encourage that activity.

Figure 1-B summarizes the provisions of the Amendments Act.

The most significant of the deadlines in the Act was Jan. 1, 1993. This 1993 date was the mandatory time by which states were required to assume responsibility for LLRW management and disposal. This date also was the deadline by which the sited states were allowed to shut off access to their disposal sites to out-of-region generators.

One provision of the Amendments Act was declared unconstitutional by the U.S. Supreme Court in June, 1992. That deadline would have required states that had not arranged for LLRW disposal by Jan. 1, 1996, to assume title to and liability for the waste for failing to take possession of the LLRW generated within their states. The suit that led to the Supreme Court's action was filed by the State of New York; Massachusetts joined several other states in submitting legal briefs in support of New York's position.

1.4 State Actions to Meet the Federal Milestones

The first LLRWPAA deadline that all states were required to meet occurred before the passage of Chapter 111H. Because that milestone was extremely general in nature, it required no more than a short letter of intent. Massachusetts achieved the first deadline with a letter In 1986 from Governor Michael Dukakis certifying the state's intention to develop an in-state disposal facility.

The second milestone required each compact region or state to prove by Jan. 1, 1988, that it had established a detailed plan for facility development and license application, plus the authority delegated to implement its LLRW management plan. Massachusetts met this deadline by submitting a copy and detailed explanation of Chapter 111H, which provided the enabling law to accomplish the requirements of the second

Figure 1-B
Milestones, Penalties and Incentives of the Federal LLRWPAA

MILESTONES	PENALTIES
By July 1, 1986, each state shall join a regional compact or certify its intent to develop an in-state LLRW facility.	**For failing the milestone:** Double the surcharge of $10/cubic foot between July 1, 1986 - Dec. 31, 1986. Access may be denied after Jan. 1, 1987.
By Jan. 1, 1988, each compact shall designate a host state, or each single state shall develop a facility siting procedure.	**For failing the milestone:** Double the surcharge of $20/cubic foot between Jan. 1, 1988 - June 30, 1988. Quadruple the surcharge of $20/cubic foot between July 1, 1988 - Dec. 31, 1988. Access may be denied after Jan. 1, 1989.
By Jan. 1, 1990, each single state or compact shall file a license application to operate a disposal facility or certify the state is both "capable of providing" and "will provide" for storage, disposal or management of LLRW requiring disposal after 1992.	**For failing the milestone:** Access to three sited states' disposal sites may be denied after Jan. 1, 1990.
By Jan. 1, 1992, each single state or compact shall file a license to operate a disposal facility.	**For failing the milestone:** Triple the surcharge of $40/cubic foot between Jan. 1, 1992 until complete license application is filed, or until Dec. 31, 1992.
DEADLINES	**PENALTIES**
By Jan. 1, 1993, each single state or compact must provide disposal capacity for all LLRW.	**For failing the deadline:** 1/36th of the rebate funds collected between Jan. 1, 1990 - Dec. 31, 1992 will be returned monthly (with interest) to the LLRW generators. Rebates continue to be returned until disposal is provided, or until Jan. 1, 1996. Access to the three sited states disposal sites may no longer be available.
By Jan. 1, 1996, each single state or compact must provide disposal capacity for all LLRW.	**For failing the deadline:** The single state or compact shall "take title to the waste, be obliged to take possession of the waste, and shall be liable for all damages directly or indirectly incurred by such generator" as a result of failing to take possession of the waste.[a]

INCENTIVES TO MEET MILESTONES AND PENALTIES

- 25% of the federally-mandated surcharge fees paid by producers of LLRW to the three sited states (S. Carolina, Nevada and Washington) shall be rebated to the state for meeting each milestone and the January, 1993, deadline.
- Continued access to the disposal sites in S. Carolina, Nevada, and Washington through Dec. 31, 1992.

[a] The U.S. Supreme Court declared this provision unconstitutional in June, 1992.

Source: P.L. 99-240, Low-Level Radioactive Waste Policy Amendments Act of 1985.

milestone. Chapter 111H established a planning process designed to ascertain the need for in-state LLRW storage, treatment, and disposal facilities. The extensive "planning" phase of this state law culminates in a vote by the Management Board whether or not to initiate siting.

The third milestone required that before Jan. 1, 1990, the Governor was either to demonstrate that a disposal facility license application had been filed or to certify that Massachusetts would provide storage, disposal, or management of all LLRW produced here after the three sited states shut off access to their sites on Dec. 31, 1992. Numerous provisions of Chapter 111H were again referenced in this certification, with detailed explanations and timetables showing how Chapter 111H would enable Massachusetts to meet the requirements of federal law.

The fourth milestone directed each state or region, prior to Jan. 1, 1992, to file a complete license application to operate a disposal facility. Chapter 111H again provided the statutory authority and established the institutional mechanisms necessary to develop an LLRW disposal facility in the state. However, the precise timing of this milestone could not be met by most states, including Massachusetts.[8] In the Commonwealth's case, a state budget crisis between 1987-1989 forced cutbacks which led to delays in LLRW management activities from the time of Chapter 111H's passage in 1987 through 1990.

1.5 Massachusetts LLRW Management: A Brief History

Since 1965, various agencies of state government and the Massachusetts Legislature have reviewed LLRW issues, and offered LLRW management suggestions. Many of those who made recommendations came to the same conclusions: that major emphasis on LLRW management should be directed towards:

- ensuring the protection of public health, safety, and the environment;
- reducing radioactive source materials that can produce LLRW, and minimizing LLRW volumes and radioactivity; and
- educating the public about both the benefits of radioactive materials use and the need to regulate this use properly to avoid potential hazards.

Following is a summary of the major LLRW-related endeavors by state government:

May, 1965: The Massachusetts Advisory Council on Radiation Protection (Council) was created by Chapter 484 of the Acts of 1965 to advise the Governor and the Legislature on issues relating to radioactive materials use and LLRW. Council membership includes representatives of various state agencies and industrial, academic, and medical producers of LLRW.

November, 1980: The Council and its Ad Hoc Committee on Low-Level Waste released a report to Governor Edward King recommending the establishment of an LLRW management program in the Commonwealth. Declaring that "the LLRW problem is solvable and ... it is important to start on the solution immediately," the Council made several other recommendations, which included: ensuring "thorough" site selection and facility development to protect health, safety, and the environment; establishing a public education program; creating an escrow account to cover the costs of site monitoring after closure; making

[8] The only states siting LLRW disposal facilities that met the 1992 deadline were California, Illinois, Nebraska, and Texas.

LLRW producers liable for accidents involving improper transportation and packaging for disposal; encouraging volume reduction; establishing an advisory committee of technical experts and citizens to evaluate new LLRW management techniques; and considering the use of state land for LLRW disposal.

The Council's report, prepared at a time when Massachusetts was the eighth largest producer of LLRW in the country (170,000 cubic feet per year), also recommended the use of shallow-land burial as the disposal technology. The present policies of state government follow many of the Council's recommendations, but not the endorsement of shallow-land burial, a disposal method expressly forbidden by Chapter 111H, due to the failure of this technology to prevent the migration of radioactivity at the former disposal sites, which all used this method.

January, 1981: Legislation was filed for the 1981 session of the Massachusetts Legislature establishing procedures for siting LLRW disposal facilities within the Commonwealth. The bill, H. 6877, which failed to become law, was modelled after an existing state law, Massachusetts General Laws c.21D, which provides a system for siting hazardous waste disposal facilities.

August, 1981: Governors in the Northeast adopted a resolution, under the auspices of the Coalition of Northeastern Governors (CONEG), supporting the pursuit of a regional compact to resolve LLRW disposal problems. The resolution established the organizational framework for what became the CONEG Low-Level Radioactive Waste Policy Working Group (CONEG Policy Working Group) and its Technical Subcommittee. Both groups began meeting in September, 1981, representing the Governors of the six New England states, New York, New Jersey, Pennsylvania, Delaware, and Maryland. They explored a broad range of technical, legal, and policy issues involved in developing a regional system for managing LLRW.

December, 1981: Due to disagreements over the contents of H. 6877, the Legislature killed that bill, and opted instead to pass Chapter 738 of the Acts of 1981. This law established the Special Legislative Commission on Low-Level Radioactive Waste (Special Commission) to evaluate the State's LLRW management situation and to make recommendations relative to transportation, treatment, processing, and disposal of LLRW, including regional disposal solutions.

October, 1982: DOE funded a project to survey all LLRW generators in the Commonwealth in order to determine the volumes and types of waste produced. The percentages of waste generated by a specific licensee type (i.e., commercial, utility, medical and academic) reported by DOE were similar to the percentages still produced today by some of these generator categories.[9]

November, 1982: The Nuclear Power and Waste Disposal Voter Approval and Legislative Certification Act, Chapter 503 of the Acts of 1982, was enacted through a ballot initiative approved by the voters. This law, which was subsequently the subject of an advisory opinion by the Massachusetts Supreme

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[9] The DOE report estimated from survey responses that 52% of the waste volume shipped from Massachusetts for disposal in 1979, 1980, and 1981 was produced by the commercial sector; 38% by utilities; 6% by medical generators and 4% by the academic sector. In 1991, these percentages were 51% - commercial; 43% - utilities; 3% - health care; and 3% - academic. In 1992, these percentages were 60% - commercial; 27% - government; 11% - utility; 1% - health care; and 1% - academic. The drop in utility LLRW generation was due to the increase in LLRW production by the other generator categories in 1992. The significant percentage of government waste was due to the decommissioning of the U.S. Army's Watertown Arsenal site. The large percentage of commercial waste identified in the DOE study continues to be the major portion of Massachusetts waste, both in volume and radioactivity.

Judicial Court,[10] requires two separate approvals by the Legislature and the majority of voters in a statewide referendum before an LLRW facility can be sited. The Chapter 503 approval procedure is as follows:

(1) After an LLRW site is selected, and the proposed facility has received all necessary "federal, state and local permits," a petition for approval is submitted to the state Legislature.

(2) Following legislative review, the Legislature may reject the petition, or indicate its approval by adopting a resolution certifying that both "superior" technology and a "superior" site are included in the proposal. The Legislature must include with its resolution an appendix of facts supporting its approval, which justify the site and facility on their "overall cost, reliability, safety, environmental impact, land-use planning and avoiding social and economic dislocation."

(3) If the Legislature approves a resolution, the Secretary of State must place it on a State Election ballot for voter approval.

(4) If the voters also approve the resolution, then the facility may be built.

February, 1983: The Massachusetts Department of Public Health (DPH) issued a "Proposed Low-Level Radioactive Waste Management Plan" for the Commonwealth. The plan, prepared by a task force comprised of diverse interests, and funded by DOE, was developed as an "initial guide to policy level decision-making" for DPH. Among the recommendations proposed were:

- Massachusetts should become an Agreement State to assume the NRC's regulatory authority over licensing radioactive materials users and LLRW disposal;
- the responsibilities of facility siting and facility licensing should be handled by separate state agencies;
- each licensee should complete an annual survey of waste quantities, radiological and chemical characteristics, and projections of future volume;
- DPH should study disposal technologies to determine which is most suitable for Massachusetts;
- Massachusetts should establish an LLRW volume reduction policy; and
- DPH should study the feasibility of retrofitting existing Incinerators to burn radioactively-contaminated waste and establishing a centralized Interim waste storage facility. (This recommendation did not have support of all Task Force members.)

February, 1983: The CONEG Policy Working Group issued its final draft Northeast Low-Level Radioactive Waste Compact for consideration by the 11-state region. The draft compact had four major provisions:

(1) It apportioned the key roles and responsibilities of host states, party states, and the regional

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[10] On June 12, 1986, the Massachusetts Supreme Judicial Court issued an opinion that the legislative certification and voter approval provisions of Chapter 503 pertaining to the siting of an LLRW facility could not be constitutionally incorporated into the regulatory structure established by Chapter 111H. [Opinion of the Justices, 397 Mass. 1201 (1986)] Because the Legislature enacted Chapter 111H after the court's opinion was issued, questions have been raised about the applicability of Chapter 503.

commission. Major responsibilities included the development of a regional facility in a timely manner, and the financial commitment of party states and the regional commission to a coordinated regional approach to LLRW management.

(2) It established the Northeast Interstate Low-Level Radioactive Waste Commission, which would advise and coordinate the administration of the compact. The commission would function as a regional government body, and ensure that the interests of all states in the region were considered in the siting, development, and management of a regional facility.

(3) It established a process for selecting a regional host state, but did not specify how the host state would site, develop, and oversee the regional facility.

(4) It established the terms and conditions for compact membership and withdrawal.

(5) It assigned legal liability for LLRW disposal.

June, 1983: Governor Dukakis submitted the CONEG compact to the Massachusetts Legislature as H. 6451, declaring that, of the options available to the Commonwealth, joining a regional compact is the "most sensible and forward-looking choice" for the management of LLRW. The Special Commission held a series of five statewide public hearings on the CONEG compact, as required by Chapter 738, and received a substantial amount of testimony that the Northeast Compact, as drafted, would not adequately protect and serve Massachusetts' interests. The bill to ratify the CONEG compact ultimately died during the 1983 legislative session. (See Chapter 6 of this volume, which discusses the Massachusetts problems with the CONEG proposal, and also details the Commonwealth's efforts to establish an out-of-state disposal agreement).

The Special Commission established two sub-committees to assess opinions on the CONEG compact expressed at the public hearings. The Economic and Technical Sub-Committee researched the feasibility of smaller disposal facilities, questions of liability, packaging, source and volume reduction, and alternative technologies to shallow land burial. The Legal Sub-Committee reviewed issues of a Massachusetts-only facility and repeal of inconsistent state laws (a provision of the CONEG document). In April, 1984, legal counsel to the Special Commission issued a report on a number of these questions.

April, 1984: Massachusetts' representatives on the CONEG Policy Working Group (who were also the Senate and House chairmen of the Special Commission), presented the Special Commission's preliminary alternative draft compact to other CONEG Policy Working Group members, who discussed the progress of the CONEG compact in their respective states. Most of the other 10 Policy Working Group states also had not enacted the CONEG draft, the major impediments being the host state selection process and the host state rotation process as proposed by the CONEG draft. (The CONEG compact would have authorized the regional commission to force a facility upon an unwilling host state, if no state volunteered to host the regional facility.)

September, 1984: The Special Commission presented its redrafted CONEG compact to Governor Dukakis for use in future compact discussions. (See Chapter 6, Appendix 6B). However, no other state was interested in joining a compact with Massachusetts unless Massachusetts assumed responsibility for siting. Since that time, no other work on explicit compact language has occurred.

February, 1985: The "First Report" of the Special Commission made a number of key recommendations, including that:

- the state negotiate with other states in the region to determine mutually agreeable conditions for a regional compact, using the Special Commission's compact document as a starting point for

such discussions;

- the state not establish an interim centralized storage facility for LLRW, because such an effort would be a major undertaking requiring siting, design, licensing, and construction and, thus, would divert attention from the primary task of developing permanent LLRW disposal capacity;

- if an LLRW disposal facility is sited and built in the Commonwealth, the state should become a "limited" Agreement State and assume regulatory responsibility for licensing a disposal facility, or a "full" Agreement State and assume, in addition, regulatory responsibility for licensing most users of radioactive materials. The Special Commission proposed legislation designed to allow Massachusetts to seek either limited or full Agreement State status. That legislation was adopted as part of Chapter 549 of the Acts of 1987.

April, 1985. The Special Commission retained two environmental engineering consulting firms to update information about the volumes and characteristics of LLRW and to evaluate various management options. This study predicted that between 1986 and 2020, Massachusetts LLRW generators would produce 5.1 million cubic feet of waste. This projection was lower than earlier estimates, due to the extensive use of waste minimization anticipated in the study.

January, 1986: The Special Commission released its "Second Report" recommending that its Low-Level Radioactive Waste Management Act be approved by the Legislature. That legislation proposed a comprehensive framework for the management of LLRW in the Commonwealth.

December, 1987: The Management Act recommended by the Special Commission was approved by the Legislature with only a few changes from the Commission's original draft. It was signed by the Governor as part of another law directing the Management Board, on behalf of the Commonwealth, to proceed on a dual path of (1) compact negotiations with any states that may be willing to site a disposal facility and accept Massachusetts LLRW, and (2) planning for the possibility of in-state siting. (See Appendix A and B at the end of this volume for the full text of the two laws).

The Management Act, Massachusetts General Laws c.111H (Chapter 111H) was written to avoid the problems of other state siting laws. Chapter 111H requires that a determination be made of the need for LLRW storage, treatment, and disposal facilities, and to establish detailed plans and regulations, before any siting is initiated. It prohibits the use of "shallow land burial" landfill-type disposal, and requires that any waste placed into a disposal site must be able to be monitored for the entire period that the waste is in the facility, as well as retrieved, if necessary. Because of these provisions of the law, in effect, Chapter 111H envisions that any disposal facility built in Massachusetts would in actuality serve as a "long-term storage" location, rather than a traditional "disposal" site in which waste is placed, and then forgotten.

July, 1988: The seven "public" appointments to the Management Board were made by Governor Dukakis from lists of candidates nominated by statewide organizations that had demonstrated interests in the areas of professional training and experience required of Board members (i.e., public administration, engineering, radiological health, business management, and environmental protection).

Since 1990: The three state agencies responsible for various areas of LLRW management (the Management Board, DPH and the Department of Environmental Protection (DEP), have worked to complete the requirements of the Chapter 111H planning phase, and to fulfill the mandates of federal law. In addition, numerous discussions have occurred between the Commonwealth (through the Management Board and other officials) with every regional compact commission and individual state that may allow Massachusetts LLRW generators access to their existing and newly-developing disposal facilities. The Management Board's efforts on behalf of the Commonwealth, to identify a compact or contract agreement to allow disposal of Massachusetts-produced waste outside the Commonwealth, are detailed in Chapter 6.

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Chapter 1A: LLRW Commercial Disposal Sites: Operations and Problems

Between 1962 and 1971, six sites were established for the disposal of commercial low-level radioactive waste (LLRW). They were located in Barnwell, South Carolina; Beatty, Nevada; Hanford, Washington; Maxey Flats, Kentucky; Sheffield, Illinois; and West Valley, New York. Three of these sites (Maxey Flats, Sheffield and West Valley) closed between 1975 and 1978, due to various operational and environmental problems. These included water infiltration into trenches; movement of radioactivity out of trenches; geologic unsuitability; poor management methods; and inadequate funds for closure and institutional control.

A seventh site for the disposal of limited types and concentrations of radionuclides in the LLRW was opened in Clive, Utah, in 1988, initially accepting only naturally-occurring radioactive material (NORM), which is radioactive material or waste that has a natural source (such as natural deposits of radium). That site is the only LLRW disposal site owned and operated by a private firm, Envirocare of Utah, Inc. All other disposal sites were initiated by state governments, which contracted out site development and site operation to private LLRW management companies for a specific number of years. A detailed description of the Envirocare site can be found at the end of this appendix.

The descriptions of the problems at various sites point out the changes in philosophy and public policy since these sites opened. The major change was the adoption by the U.S. Nuclear Regulatory Commission (NRC) of Title 10 of the Code of Federal Regulations (CFR), Part 61. These regulations established standards regarding waste form, waste stability, and other disposal requirements intended to prevent the site problems of the past. For example, most states developing new LLRW disposal facilities prohibit the use of the shallow land burial method of disposal. Massachusetts law includes an explicit statutory prohibition on that method. In addition, Massachusetts law requires that, if an LLRW disposal facility were sited and operated in the Commonwealth, it must allow monitoring and retrieval, if necessary, of the LLRW packages, so that any problem could be detected and corrected long before the radioactivity in the waste could damage public health, safety, or the environment.

All seven sites are summarized below.

Beatty, Nevada

The LLRW disposal site in Beatty, Nevada, was the first to be licensed by the AEC for commercial operation. The State of Nevada owns the 80-acre site, which is located 11 miles south of Beatty and 105 miles northwest of Las Vegas. A hazardous waste disposal facility operates adjacent to the LLRW site, separated by a 200-foot buffer zone and a security fence.

The site is situated in the Amargosa Desert, about 2,800 feet above sea level. The groundwater table lies about 260 to 330 feet below the surface in deposits of sand, silt, and gravel.

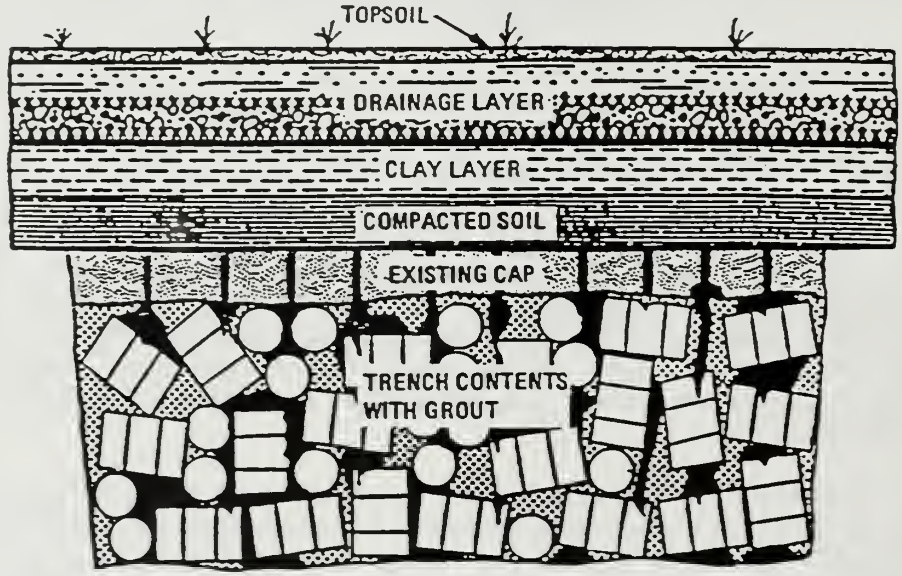
No continuous surface water source exists within 10 miles of the site, and the closest river flows intermittently five miles away. The average yearly rainfall at the site is 2.5 to 5 inches, and the evaporation

rate is roughly 100 inches per year.

The 22 trenches at the site are of varying sizes, ranging from 300 to 800 feet long, four to 350 feet wide, and six to 50 feet deep.

Before the Beatty site closed on Dec. 31, 1992, a forklift or crane was used to place waste packages into the trenches and to stack them on top of each other in a uniform manner. As a section of a trench was filled, three to eight feet of earthen cover was placed over it, and mounded so that the center was two feet higher than the surface of the ground. Concrete markers identify dates, waste characteristics, and the boundaries of each trench.

Figure 1A-A
Maxey Flats, Kentucky Disposal Site



Source: U.S. Department of Energy

In 1981, as a result of discovering LLRW shipments with numerous transportation and packaging violations, an inspection procedure by an independent third party was established at Beatty by the State of Nevada as a condition for the disposal of all LLRW. The costs of this inspection raised disposal prices at Beatty such that most generators sent their wastes to Hanford and Barnwell, instead of using Beatty.

An agreement announced in September, 1993, between the State of Nevada and site operator US Ecology, regarding the unused disposal capacity at the Beatty LLRW site, ended all litigation that had been pending between the two parties, and allowed final closure activities to proceed at the LLRW disposal site. The agreement transferred all unused LLRW disposal acreage to the hazardous waste disposal site, doubling that facility's current capacity. Both the LLRW disposal site and the hazardous waste disposal site were operated by US Ecology.

Maxey Flats, Kentucky

Maxey Flats, the second commercial disposal site to open, operated from 1963 until it was closed in 1977. The 280-acre site is owned by the Commonwealth of Kentucky, and is situated nine miles northwest of Morehead and 65 miles northeast of Lexington, Kentucky. Approximately 25 acres were used for waste disposal.

The site sits over a silty clay which is one to 10 feet deep. Underneath the clay are layers of siltstone, sandstone, and shale in varying layers and different thicknesses. The portion of the site containing the trenches lies within a geologic formation of shale that becomes hard and impermeable when moist, and can, therefore, slow the movement of water.

Most of the runoff of surface water drains into No-Name Creek to the east of the site; there are creeks on two other sides as well. The average annual rainfall is 46 inches.

In addition to the 52 trenches ranging in size from 150 to 680 feet long, 10 to 75 feet wide, and nine to 30 feet deep, the site also has several "hot" wells and "special pits." Both the hot wells and the pits were used to dispose of "high activity" wastes -- LLRW that contains higher than average levels of radioactivity.

During operation of this site, each trench was fully dug before any waste was placed into it. Once filled, each trench was covered with a minimum of three feet of clay-like soil, and two to three feet of earth, mounded to encourage water runoff.

This site was plagued by water accumulation, due to the low permeability of most of the site soils, and the high rate of precipitation. Rain water accumulated in the trenches and eventually filled them. In mixing with the buried LLRW, water became radioactively contaminated, overflowed from the trenches, and migrated off the waste management area. In 1973, the Commonwealth of Kentucky required the site operator to begin a water management program which consisted of pumping the several million gallons of radioactive water out of the trenches and into above-ground holding tanks for treatment. However, poor administration of this program caused greater contamination of surface runoff, which spread a growing plume of contamination at the site. In addition, there were umerous incidents of waste spillage and of radioactive water in the trenches being unintentionally dispersed by earth-moving equipment.

After the site was closed in 1977, water management continued. In 1981, a plastic cover was placed on the surface over a portion of the trenches, and drains were installed to direct surface water away from the trenches. When radiation was found adjacent to the disposal areas in 1983, Kentucky sought relief through the federal Superfund process which identifies responsible parties, develops a remedial investigation and feasibility study, and chooses a final clean-up strategy.

In 1986, the U.S. Environmental Protection Agency (EPA) listed the Maxey Flats site on its Superfund "National Priorities List," and assumed the lead oversight role for site cleanup. The layers of soil, clay, synthetic covers, crushed rock, sand, and topsoil capping the disposal trenches are shown in Figure 1A-A. The "Record of Decision" describing EPA's approved remedial action plan was signed in September, 1991. Site remedies include:

- excavation of additional disposal trenches for the disposal of site debris and solidified leachate;
- demolition and on-site disposal of site structures;
- continued extraction, solidification, and on-site disposal of trench leachate;
- maintenance of the plastic cover that acts as an infiltration barrier over 28 acres of the site (around the waste disposal area);
- continuous monitoring of groundwater, surface water, and air;
- acquisition of 200 to 400 acres of land adjacent to the site boundary to prevent deforestation or other activities that would accelerate erosion and affect the integrity of the mitigation program, and to provide for frequent and unrestricted access to areas adjacent to the site for monitoring purposes;
- five-year reviews to evaluate the protectiveness of the remedy; and
- institutional controls to ensure monitoring and maintenance.

Over 832 potentially responsible parties, comprising the companies, institutions, and individuals who sent LLRW to the site, have been identified for purposes of recovering cleanup costs. The estimated cost of the EPA mitigation plan (in 1991 dollars) is $33,500,000.

West Valley, New York

The LLRW disposal site at West Valley in the town of Ashford was one of several operations at the Western New York Nuclear Services Center. Other activities on the 3,345-acre site, which is 30 miles southeast of Buffalo, included a commercial nuclear fuel reprocessing plant, a spent fuel storage facility, a storage facility for liquid high-level radioactive waste, and a land disposal area for solid, long-lived waste, including spent fuel hardware from nuclear power plants.

A 22-acre site in the middle of the Nuclear Service Center was licensed for LLRW disposal because state officials believed the site possessed relatively good surface drainage, low soil permeability, and an absence of near-surface groundwater. The disposal site was situated over a 10 to 12-foot layer of silty clay, gravel, and rock (known as weathered till) which overlay a 150 to 300 foot layer of unweathered till. Below the till was a strip of bedrock shale and siltstone 500 feet or thicker.

The site contains 14 trenches 30 feet wide, 20 feet deep, and 600 feet long. (Figure 1A-B) They were developed in two stages, and problems at the first group of trenches (such as collapsed walls, level rather than sloped trench floors, and insufficient cap and cover) led to improved practices at the second set of trenches. The second group of trenches was used between 1969 and 1975, when the site was closed. These trenches were dug shallow at one end, and deeper at the other. The waste was placed into the shallow end first, so that any water entering the trenches during construction would collect at the deeper end. From there, it was pumped into lagoons for treatment and disposal.

Waste was placed manually into the trenches, with the exception of heavy packages or those with high levels of surface radiation. The containers were placed in rows horizontally, and stacked vertically. As each section of trench was filled, it was covered with an earthen cap of four feet minimum until 1968, when the cap was increased to eight feet, because of water infiltration.

Site monitoring revealed that water had accumulated in the trenches during the first few years after each trench was capped. When water in some of the trenches rose to the level of the earthen cap and seeped through, the site operator was required to cease disposal operations until New York State's conditions for reopening were met. The site was never reopened, and various corrective actions have been taken since 1975 to reduce water infiltrating into the trenches.

Radioactivity from the Western New York Nuclear Services Center has been found off site. One account from an individual from the State's Department of Health attributes off-site radioactivity to effluents from the fuel reprocessing plant, and to the LLRW site.[1]

As noted, water infiltrated the trenches of the LLRW site, and overflowed. During site operations, the site operator pumped much of this contaminated water out of the trenches, and into local streams. Subsequent remedial action was initiated, which involved pumping treated trench water, and discharging it to local streams. The Matuszek paper notes that, "Radionuclides from the burial site, even during periods when the trenches were pumped, cannot be identified above ambient levels at any of the public water supplies downstream."

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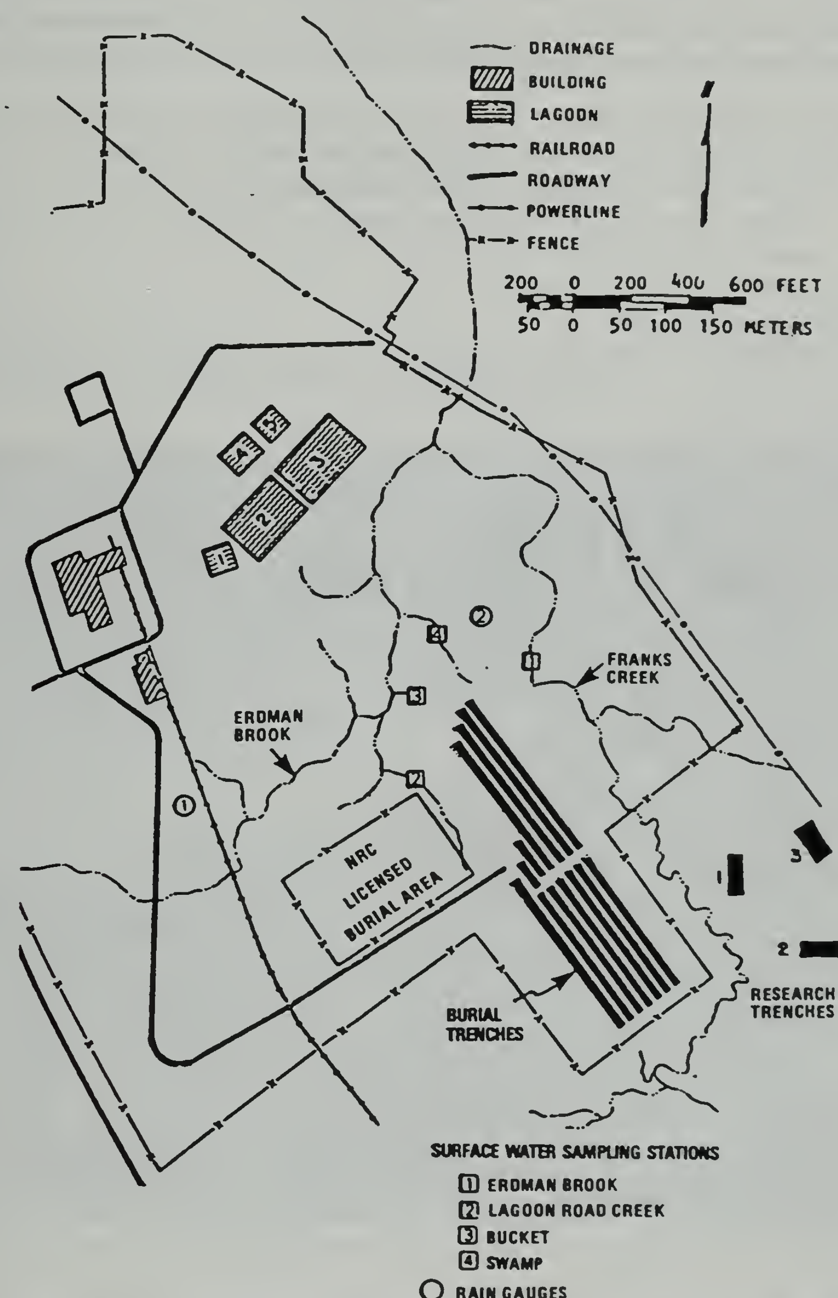
[1] Matuszek, J.M. "Safer than Sleeping with Your Spouse -- The West Valley Experience." From Low-Level Radioactive Waste Regulation: Service, Politics and Fear. Edited by M. Burns. Lewis Publishers, Inc., Chelsea, MI, 1988.

Figure 1A-B
Location of Burial Trenches and Research Trenches
at West Valley, New York Disposal Site



Source: U.S. Department of Energy. National Low-Level Radioactive Waste Management Program,Idaho Falls, ID: February, 1986.

Some support exists in Ashford to complete the remedial action plans so that a new, state-of-the-art LLRW disposal facility may be constructed on the property. The New York Legislature has been considering

legislation to accomplish this goal.

Hanford, Washington

The Hanford LLRW disposal site occupies 100 acres of a 1000-acre tract on the Hanford Reservation, which is leased by the State of Washington from the Department of Energy (DOE). A secondary lessee, US Ecology, Inc., has operated the LLRW site since it opened in 1965. (Figure 1A-C)

Figure 1A-C
Hanford, Washington Disposal Site

The disposal site rests on about 200 feet of sand, silt, and gravel deposits which overlie a thick layer of sedimentary material and bedrock. The water table lies about 200 to 360 feet below the land surface. No surface water exists on the site, and the nearest river is six miles away. The climate is semi-arid, with an annual rainfall of 6.3 inches, and a yearly possible evaporation rate of 55 inches.

There are 14 trenches presently on the site, which vary in size from 300 to 850 feet long, 25 to 140 feet wide, and 20 to 45 feet deep. Waste containers fill the trenches up to eight feet from the ground

surface. The soil excavated from the trenches is then placed on top of the waste containers, mounded to a level five feet above original ground surface in the center, and three feet above ground surface at the trench edge. Six inches of gravel and cobble are placed on top of the soil. Like the other sites, the boundaries of each trench are marked.

Also on the site are four cylindrical 30-foot deep borehole disposal units lined with steel pipe and sealed with concrete at both ends. These structures were used for the disposal of high activity LLRW.

In addition, the site had five underground steel tanks that were used during the first few years of operation to evaporate and solidify liquid resin LLRW. Although use of these tanks was discontinued in the early 1970s, the tanks themselves and the wastes inside were left in place until contamination of adjacent soil was discovered in 1985. At that time, the liquid waste and two tanks were removed. The remaining three tanks were filled with concrete, and plastic was placed over the tank area to prevent wind erosion of contaminated soil.

The LLRW site is monitored continually by the operator, the State of Washington, and DOE. No movement of radionuclides has occurred outside the disposal trenches.

Washington is a member of the Northwest Interstate Compact, which also includes the States of Alaska, Hawaii, Idaho, Montana, Oregon, Utah, and Wyoming. It has agreed to serve as host state to that compact region for an indefinite period of time, and has also negotiated a contract with the Rocky Mountain Compact states (Colorado, Nevada, and New Mexico) to dispose of their waste after the closure of the Beatty, Nevada, site in December, 1992. A study done in 1984 estimated that the Hanford site could continue taking all the LLRW in the nation requiring disposal, for 33 to 66 years.

Sheffield, Illinois

The Sheffield site opened in 1968 on 190 acres of land adjacent to two hazardous waste disposal areas. The site is five miles southwest of Sheffield and about 145 miles southwest of Chicago.

The site is located in a layer of soil, sand, and silt 100 feet thick, which rests on top of 100 feet of pebbly sand and another 300 feet of shale. Both a shallow and a deep aquifer exist underneath the site, and the layer of pebbly sand drains most of the groundwater from the site. A creek is located one mile east of the site, and three small, intermittent streams also provide surface drainage. The site receives about 35 inches of rain yearly, which is only 90% transmitted to the atmosphere by evaporation of water from the earth, and transpiration of water from plants.

For the 10 years that Sheffield was in operation, LLRW was disposed of in 21 trenches, 500 feet long, 50 to 60 feet wide, and 20 to 25 feet deep. During investigations in the mid-1970s relating to the operator's petition to the NRC for a license modification to allow excavation of new trenches, radioactive contaminants were discovered to be migrating from the trenches, and re-evaluations of groundwater movement showed a rate far exceeding earlier estimates. After permeable sand and other materials were found to be more extensive in the area proposed for expansion, the NRC ruled against using this area for waste disposal. Because no space existed in the other trenches on site, operations ceased, and the site closed in April, 1978.

Radioactive contamination to the groundwater at this site has resulted from water entering the trenches through eroded trench caps, and the relatively high permeability of some of the materials underneath part of the site.

One month before it closed, the site operator, US Ecology, attempted to end its license and lease with the State of Illinois. Because Illinois did not want to assume the costs of cleanup and institutional con-

trol, the State sued US Ecology. An agreement was reached later that year, which required US Ecology to maintain the site for 10 years before it was turned over to Illinois. The operator also agreed to establish a $2.5 million long-term care fund and a $1.65 million escrow account, to make physical improvements to the site, and to begin a chemical and radiological monitoring program.

Part of the site improvements included building a clay cap over the entire site, which was completed in 1989. US Ecology is installing new monitoring wells at the site, and its environmental monitoring program will test ground and surface water, soil, vegetation, and fish.

Barnwell, South Carolina

Barnwell was licensed in 1969 as an above-ground LLRW storage facility. In 1971, the site operator, Chem-Nuclear Systems, Inc., received a license amendment to bury LLRW on the 300-acre site, which is adjacent to DOE's Savannah River Plant, and a federal LLRW disposal site. The LLRW disposal site is in the southwestern portion of the state, five miles west of the small town of Barnwell. (Figures 1A-D and 1A-E)

Figure 1A-D
Barnwell, South Carolina Disposal Site

Source: Chem-Nuclear Systems, Inc.

The site is located in layers of sand and clay topsoil overlying a thin (two to seven feet) layer of sand, and a thicker (14 to 30 feet) layer of clay. The water table lies within and below the clay layer at depths of 30 to 60 feet, but the main source of drinking water for the area comes from a deeper aquifer

approximately 350 feet below the surface.

A creek is located three miles from the site, and drains a large portion of the site. The sandy topsoil absorbs most surface water runoff. The annual rainfall ranges from 29 to 73 inches, with about 15 inches infiltrating yearly to the water table.

Two types of trenches are used on site. The first four of 73 existing standard trenches are 200 feet long by 50 feet wide, and 15 feet deep. The newer trenches are 1,000 feet long, 100 feet wide, and 21 feet deep. The "slit" trenches are 500 feet long, four feet wide, and 22 feet deep.

Figure 1A-E
Barnwell, South Carolina Disposal Site

The trenches slope to one side where a drain filled with rock fragments (i.e., a "French drain") runs the length of the trench and collection sump pumps are located at 500-foot intervals along the drain. Standpipes to remove leachate are in the sumps and at other places along the trench. Sand is placed in the bottom of the trenches to ensure that any water in the trench will drain into the French drain and be collected in the standpipes. The trench walls are lined with compacted clay to reduce moisture from the

surrounding soil.

Once the trenches are filled with stacked waste containers, sand is placed around the containers to fill any void spaces, and three feet of soil is placed over the top. Next, a layer of compacted clay two feet deep and topsoil six to 18 inches thick is placed over the clay. The trench boundaries are marked for monitoring purposes.

"Slit" trenches are used for higher activity LLRW, because the narrow trench helps minimize worker exposure during disposal. Several feet of gravel is placed in the trench floor and clay is backfilled over the waste containers. Once they are filled, clay and concrete covers are placed over the trenches.

In late 1992, the South Carolina Legislature approved a law extending the availability of the Barnwell site through 1995 for generators within the Southeast Interstate Compact region (Alabama, Florida, Georgia, Mississippi, North Carolina, Tennessee, and Virginia), when the compact's new regional site is expected to open in North Carolina.

The same South Carolina law authorized the Barnwell site to remain open to out-of-region LLRW generators through June 30, 1994, conditioned upon the approval of two-thirds of the members of the Southeast Compact Commission. The Management Board successfully negotiated a contract for this additional access for Massachusetts generators.

In October, 1993, the Barnwell site operator, Chem-Nuclear Systems, Inc., announced its intention to lobby the South Carolina Legislature for a change in the new law, in order to extend the site's availability beyond June, 1994, for out-of-region generators.

Clive, Utah

Envirocare of Utah, Inc., a subsidiary of S.K. Hart Engineering, opened its naturally-occurring radioactive materials (NORM) disposal facility in February, 1988. The site is located in Tooele County, three miles south of Interstate 80 in Clive, and more than 30 miles from any farming or residential areas.

The desert site contains low-permeability clay soils. The arid climate results in an annual precipitation rate of approximately 4.8 inches, and an annual evapotranspiration rate of more than 60 inches.

The Envirocare site was originally used by DOE and the State of Utah as a disposal area for 75 million cubic feet of radioactive mill tailings from the former Vitro Company of Salt Lake City, that operated during the 1950s and early 1960s. The DOE disposal project was completed in 1989. Up until 1991, the site accepted only NORM material and certain types and concentrations of radionuclides in the LLRW, under license from the State of Utah, which is an Agreement State.[2] In 1991, the company received a license from the NRC to dispose of uranium and thorium byproduct material (as defined by section 11e(2) of the Atomic Energy Act). The NRC license was necessary because Utah's Agreement State authority does not cover section 11e(2) byproduct material.

The total shallow land burial disposal area is one square mile. Envirocare is authorized to dispose of 144-162 million cubic feet in total. As of December, 1993, 100 acres of the site had been used, and 27 million cubic feet of LLRW had been disposed of.

Envirocare also received a "Part B" permit from the EPA in 1990 to allow disposal of certain "mixed" wastes, LLRW that is contaminated by or exhibits the characteristics of toxic chemical "hazardous" materials.

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[2] See detailed discussion of the Agreement State program in Chapter 2.

Table 1A-1
Radionuclides Acceptable at the Envirocare Disposal Facility
(picocuries per gram)

Radionuclide	Concentration	Radionuclide	Concentration
Americium-241	230	Antimony-125	5,300
Americium-243	1,700	Tin-113	730,000
Beryllium-7	38,000	Strontium-90	20,000
Calcium-45	400,000,000	Thorium-230	15,000
Cadmium-109	46,000	Thorium-232	680[1]
Cobalt-56	360	Uranium-234	37,000
Cobalt-57	19,000	Uranium-235	770
Cobalt-58	1,600	Uranium-236	26,000
Cobalt-60	360	Uranium-238	28,000
Chromium-51	8,400	Uranium-natural	18,000
Cesium-134	38,000	Uranium-depleted	1,400,000
Cesium-137	560	Zinc-65	10,000
Europium-152	1,700	Carbon-14	400,000
Europium-154	1,400	Hydrogen-3	20,000,000
Iron-55	1,800,000	Iodine-129	10,000
Mercury-203	19,000	Sodium-22	780
Potassium-40	10,000	Technetium-99	10,000
Iridium-192	2,500	Curium-242	1,400,000
Manganese-54	5,600	Curium-242	8,100[1]
Niobium-94	160	Curium-243	1,500
Nickel-59	700	Curium-243	1,300[1]
Nickel-63	2,000,000	Curium-244	10,000
Lead-210	230,000[1]	Curium-244	7,400[1]
Polonium-210	20,000	Neptunium-237	2,000
Radium-226	2,000[1]	Plutonium-238	10,000
Radium-228	1,800	Plutonium-238	8,200[1]
Radium-228 (1 yr)[2]	1,200[1]	Plutonium-239	350,000
Radium-228 (5 yrs)[2]	670[1]	Plutonium-240	10,000
Radium-228 (10 yrs)[2]	560[1]	Plutonium-241	350,000
Ruthenium-106	19,000[1]	Plutonium-241	1,100[1]
Antimony-124	790	Plutonium-242	10,000

[1] Daughters are assumed to be present at same concentrations in equilibrium.
[2] Time after separation of RA-228 from daughter products.

Source: Envirocare of Utah Inc., December, 1993.

The site's permitted mixed waste capacity is 900,000 cubic feet; as of December, 1993, approximately 100,000 cubic feet of mixed waste had been placed into the site.

With its NRC byproduct license, its State of Utah NORM and LLRW license, and its EPA Part B permit, this site is eligible to receive LLRW containing the radionuclides and concentrations listed in Table 1A-1.

Because of the low levels of radioactivity of the waste disposed of at Envirocare, the company can accept waste packaged by a variety of methods, including individual packaging and bulk shipment. Bulk transport includes the use of gondola railcars, intermodal containers, and dump trucks. Individual packaging includes metal box containers of various sizes, metal drums, and polyethylene bags.[3] The Envirocare site has a rail spur connecting it with the Union Pacific Railroad line one mile away.

Waste is placed in the disposal cell, spread into 12-inch lifts, and compacted to the required density. When a cell reaches full capacity, it is entombed with the addition of a seven-foot clay radon barrier, and a filter zone of two feet of rock evenly spread over the disposal cell embankments to prevent erosion and to protect against any probability of floods for a 1,000 year period. Roads around the perimeter of the cells, drainage ditches, and security fences surrounding the embankments, are designed to isolate the waste material.

In 1987, Utah granted an exemption to Envirocare from the land ownership requirements of Utah's Agreement State radiation control regulations. Those regulations parallel the NRC requirement in 10 CFR Part 61.6 that LLRW disposal must occur on land owned by the federal government or a state. In 1992, US Ecology, operator of the Hanford, Washington, LLRW disposal site (and a potential competitor for some of the LLRW shipped to Envirocare),[4] petitioned the NRC to challenge Utah's exemption of the government land ownership requirement.

In June, 1993, the NRC accepted Utah's rationale for the exemption, with certain conditions, believing that Utah's level of site control would be equivalent to the control provided by government ownership. Those controls include the zoning of the site area for heavy manufacturing-hazardous materials use; Envirocare's agreement to comply with land use restrictions to control post-closure site activities (as outlined in 40 CFR, Part 264.117(c)); the company's agreement to provide "as built" drawings twice a year, showing each generator's waste as segregated from others; the company remaining responsible for the site throughout the institutional control period; and the establishment of a trust agreement giving Utah exclusive control over an institutional control trust fund to ensure that site closure and stabilization is completed by Envirocare.

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[3] Plastic bags are prohibited for LLRW disposal under the NRC's disposal regulations, 10 CFR Part 61.

[4] Concern expressed by the operation of the Envirocare site within the Northwest Interstate Compact of states, where the Hanford, Washington, LLRW disposal site is legally authorized to accept all LLRW from the region, led to the adoption of a resolution by the Northwest Compact Committee In May, 1992. The resolution allows Envirocare to accept only mixed LLRW and large volume, low-radioactivity bulk waste from a single site (but not a utility) of the following kinds: soils, process sludge, and decontamination, decommissioning, construction and demolition rubble such as concrete, cinder blocks, rebar, and asphalt.

Chapter 2: The Regulatory Framework for Managing Low-Level Radioactive Waste

2.1 Introduction

The management of low-level radioactive waste (LLRW) begins long before any waste is produced by approximately 450 licensed or registered users of radioactive materials in the Commonwealth,[1] which comprise 1.9% of the 23,000 academic, medical, government, and commercial licensees in the nation.

The licenses issued to radioactive materials users control the type and quantity of materials they may possess. Each user is responsible for managing the radioactive materials and any LLRW generated, including the disposal of these materials, in compliance with all applicable federal, state, and local laws and regulations.

This chapter briefly describes the statutory basis, responsibilities, and regulatory authority of the chief federal, state, and local agencies involved with radioactive materials and LLRW management. Massachusetts General Laws c.111H (Chapter 111H), known as the Low-Level Radioactive Waste Management Act, is detailed in Section 2.3 on state responsibilities. In addition, this chapter enumerates the procedural requirements and impacts to the Commonwealth of becoming an "Agreement State," a program that transfers various regulatory responsibilities over licensed radioactive materials users and LLRW from the Nuclear Regulatory Commission (NRC) to the State.

2.2 The Federal Role in LLRW Management

The major federal agencies with regulatory authority over radioactive materials and LLRW, and the laws authorizing their participation, are summarized here.

U.S. Department of Energy

Authorized by the U.S. Atomic Energy Act (AEA) of 1954, the Low-Level Radioactive Waste Policy Act of 1980, and its Amendments of 1985, the U.S. Department of Energy (DOE) is the lead federal agency for LLRW management. Its responsibilities include assisting states, LLRW generators, the scientific community, local governments, and interested organizations in implementing a national LLRW management system. DOE runs its National Low-Level Waste Management Program through its Idaho Operations Office and its lead federal contractor, EG&G Idaho, Inc.

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[1] The number of licensed and registered radioactive materials users varies yearly in Massachusetts as companies, universities, and other "users" acquire additional licenses and registrations, or terminate old ones.

Among the activities of DOE's management program include funding an organization of state officials, known as the LLW Forum, which meets quarterly to discuss LLRW management policies. DOE also provides technical assistance to states on a range of LLRW management issues. In 1990-1991, DOE funded a technical assistance project on waste minimization for the Massachusetts Low-Level Radioactive Waste Management Board. In 1993-1994, DOE funded an economic analysis of Massachusetts in-state disposal facility costs versus out-of-state disposal costs.

DOE also uses radioactive materials in federal research programs, and produces LLRW. It operates several LLRW storage and disposal sites for its own waste, and shares information gained from research conducted at those sites.

The DOE sites are identified in Figure 1-A of Chapter 1.

U.S. Nuclear Regulatory Commission

The NRC also receives its authority from the AEA, as well as the Energy Reorganization Act of 1974. The NRC controls the use and management of most radioactive materials and LLRW. Its numerous regulations Include:

- standards to protect against radiation hazards for those licensed to use radioactive materials; [10 Code of Federal Regulations (CFR) Part 20]
- general rules for licensing byproduct material;[2] [10 CFR Parts 30 and 31]
- licensing the manufacture or transfer of items containing byproduct material; [10 CFR Part 32]
- medical use of byproduct material; [10 CFR Part 35]
- licensing and radiation safety requirements for well logging; [10 CFR Part 39]
- licensing the use of source material; [10 CFR Part 40]
- requirements for the disposal and storage of high-level radioactive waste and spent nuclear fuel;[3] [10 CFR Parts 60 and 72]
- licensing nuclear-powered electric generating facilities and the operators of such facilities; [10 CFR Parts 50 and 55]

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[2] "Byproduct material" is radioactive material yielded in or made radioactive by exposure to radiation incident to the process of producing or utilizing special nuclear materials; tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material. "Source material" means (1) uranium or thorium, or any combination thereof, in any physical or chemical form, or (2) ores which contain by weight 0.05% or more of uranium or thorium.

[3] "High level radioactive waste" (HLRW) means (1) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and (2) other highly radioactive materials that the NRC determines require permanent isolation. "Spent nuclear fuel" or "spent fuel" means fuel that has been withdrawn from a nuclear reactor following irradiation, has undergone at least one year's decay since being used as a source of energy in a power reactor, and has not been chemically separated into its constituent elements by reprocessing.

- environmental regulations followed by the NRC under the requirements of the National Environmental Policy Act (NEPA); [10 CFR Part 51]

- requirements for licensing LLRW disposal facilities; [10 CFR Part 61]

- licensing the use of special nuclear material;[4] [10 CFR Part 70] and

- packaging and transportation of radioactive material. [10 CFR Part 71]

Users of radioactive materials in Massachusetts are registered by the Massachusetts Department of Labor and Industries and/or licensed by the NRC. The NRC may delegate to states its authority to license and regulate commercial users (except nuclear power plants, research reactors, and federal government entities) and centralized LLRW storage, treatment, and disposal facilities. Governor William F. Weld has petitioned the NRC for Agreement State status under this program, a process described in detail later in this chapter.

U.S. Department of Transportation

In addition to the NRC, the U.S. Department of Transportation (DOT) is responsible for regulating the transportation of radioactive materials and LLRW. In contrast to NRC's responsibility over packaging and containment of waste comprising large quantities of radioactivity, DOT is responsible for packaging and shipping standards for certain radioactive materials and for general requirements on labeling, placarding, handling, and highway routing of radioactive materials and waste.

DOT's regulatory authority stems from the Department of Transportation Act of 1966, the Hazardous Materials Transportation Act of 1975, and its amendments, the Hazardous Materials Transportation Uniform Safety Act of 1990. Details of LLRW transportation regulations are contained in Chapter 9.

U.S. Environmental Protection Agency

The U.S. Environmental Protection Agency (EPA) is responsible for setting radiation standards that limit the levels of radiation exposure to the general public from the management of radioactive materials. So far, these include regulating radiation levels in air emissions and drinking water supplies. Standards are authorized under several federal laws, including the Resource, Conservation and Recovery Act (RCRA) of 1976, the Clean Air Act Amendments of 1977, the Safe Drinking Water Act (1974), and the Federal Water Pollution Control Act (Clean Water Act) of 1962.

EPA also regulates LLRW that contains material listed as hazardous waste in EPA regulations or exhibits hazardous waste characteristics defined by EPA. This waste, known as "mixed waste," was restricted from disposal at the three state-sponsored LLRW disposal sites which, through 1992, had taken non-mixed LLRW, because those sites do not meet certain restrictions for the land disposal of hazardous waste required by the Hazardous and Solid Waste Amendments (HSWA) of 1984. The Envirocare of Utah site in Clive, Utah, is permitted by the EPA to accept certain types and concentrations of radionuclides in mixed waste. A list of permitted wastes accepted at that site is contained in Appendix 1A of this VOLUME.

Mixed waste regulation is shared jointly by EPA and NRC. This dual control has caused numerous difficulties, which are discussed in Chapter 8.

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[4] "Special nuclear material" means plutonium, Uranium-233, uranium enriched in the isotopes 233 or 235, and any other material which the NRC determines to fit this category.

In addition to the above-cited authority, EPA also has responsibility for the cleanup of hazardous waste sites containing radioactive contaminants under the authority of the Comprehensive Environmental Response, Compensation and Liability Act, as amended (CERCLA) of 1983, and the Superfund Amendments and Reauthorization Act (SARA) of 1989.

U.S. Geological Survey

The U.S. Geological Survey (USGS) provides other federal agencies and states with technical evaluations of geology and hydrology relating to the disposal of LLRW.

U.S. Department of Labor

Under the provisions of the Occupational Safety and Health Act of 1970, the U.S. Department of Labor (DOL) sets occupational standards for the safe handling of radioactive materials and LLRW by workers at licensed locations. The DOL regulations have been adopted by the Massachusetts Department of Labor and Industries.

2.3 The State Role in LLRW Management

With the passage of the federal Low-Level Radioactive Waste Management Act of 1980, Congress assigned to the states the legal responsibility to provide or arrange for disposal of the LLRW produced within their boundaries.

This requirement to manage and dispose of LLRW is different from the regulatory responsibility over radioactive materials and LLRW. States are **mandated** by federal law to provide for disposal; they may regulate materials and waste if they **choose**.

The federal mandate to provide for disposal capacity requires states, including Massachusetts, to identify one or more disposal facilities inside or outside the state. The Commonwealth enacted Chapter 111H to provide the necessary management system for this purpose.

Chapter 111H establishes a strong and active state role in each area of LLRW management. It was adopted by the Legislature to avoid the problems of other siting laws, such as the State's law pertaining to hazardous waste facility siting, Massachusetts General Laws c.21D. The LLRW management law:

- establishes the overall framework for the management of LLRW, requiring public policy development to ensure the protection of public health and the environment whether or not a storage, treatment, or disposal facility is sited within Massachusetts;

- prohibits the State from establishing any storage, treatment, or disposal facility in the Commonwealth unless the Management Board makes a determination of need for such a facility, and formally votes to initiate site selection;

- plans future LLRW management needs of the Commonwealth in a phased, step-by-step approach, with each building upon the previous steps;

- provides for public participation throughout all state LLRW management activities;

- forbids the burying of LLRW in landfill-type facilities; but requires instead the use of "engineered"

disposal technology (e.g., vaults, "cells" or other structures to surround waste packages for further protection);

- requires any disposal facility developed by the Commonwealth to ensure that LLRW can be monitored and retrieved; and

- requires minimization of radioactive sources that can produce LLRW, and LLRW volumes, to the greatest extent achievable.

The law established the Massachusetts Low-Level Radioactive Waste Management Board, a new state agency as the lead entity responsible for the planning and management of LLRW policy in the Commonwealth.

Chapter 111H also placed responsibilities on two existing agencies: the Department of Public Health (DPH) and the Department of Environmental Protection (DEP).

Chapter 111H does **not** require that a storage, treatment, or disposal facility be sited in the Commonwealth. It does **not** specify where any such facility would be located if the Management Board makes the determination that one or more are needed.

Instead, the law provides for a comprehensive siting procedure, if the Management Board votes by the two-thirds majority of its full membership, to site a storage, treatment, or disposal facility in the Commonwealth. Provisions of the Act require extensive review and planning prior to that crucial vote, so that the decision to site in-state cannot be made in a casual manner.

If a siting determination is made, Community Supervisory Committees (CSCs) would be created in any city or town that undergoes detailed site characterization leading to the identification of a superior facility location. The site community CSC would select the operator to build and run the facility, and would select the type of facility technology it determines to be most advantageous to the site community.

Six "Phases" of Chapter 111H

The law divides the management of LLRW into six phases. Phase I is the most critical phase, when all key policy decisions are made to ensure environmentally-sound LLRW management within Massachusetts. Phase I requires the planning and development of all policies and regulations that would be used to implement any LLRW management decision.

Phases II through VI address siting, licensing, and operating a facility, if one is determined to be necessary, and if siting is initiated.

The major activities involved in each for the six phases are described below.

Phase I: Planning

All policies and regulations are developed in Phase I. These include policies regarding out-of-state disposal, and regulations pertaining to the identification of possible storage, treatment, and disposal sites within the State. The final step in Phase I is the determination, by the Management Board, whether or not to site a facility in-state, or to choose some other LLRW management option.

The Management Board's responsibilities under Phase I include:

- developing this Management Plan to guide decision-making about the safe and efficient management of LLRW. The required elements of the Management Plan are summarized in Table 1-1;

- developing regulations to implement this Management Plan;

- preparing regulations that set financial, technical, and management criteria to be used by the Management Board in certifying applicants to develop and operate a facility and that may assist the site community in selecting an operator from among those certified to develop and run the facility; and

- determining if it is "necessary and appropriate" to proceed with site selection.

DPH is named in Chapter 111H as the chief regulatory agency. Its duties under Phase I include:

- developing regulations for reduction of the radioactive sources that generate LLRW, LLRW volume minimization, and storage for decay;

- drafting regulations for the licensing, development, operation, closure, post-closure observation and maintenance, and institutional control of storage, treatment, or disposal facilities; and

- preparing an impact report describing the "significant public health, environmental, social, and economic impacts of its LLRW management practices and regulatory programs, and the major regulatory approaches and performance objectives[5] that DPH considered but did not incorporate into its storage, treatment, and disposal facility-related regulations.

DPH is prohibited from licensing any "landfill" type of LLRW facility. Chapter 111H explicitly prohibits this type of disposal, commonly called "shallow land burial."[6] Section 16 of Chapter 111H, which details further requirements of the DPH facility regulations, also requires that any disposal method used at the facility must permit "retrieval and monitoring" of the waste.

DEP is required under Phase I to develop regulations establishing the criteria for the identification and selection of facility sites, guidelines, and procedures for selection of superior sites, to be used by the Management Board if a siting decision is made. Minimum site suitability requirements, which are summarized in Table 2-1, are specified in Chapter 111H to ensure that the siting process identifies environmentally-suitable locations for LLRW disposal within the Commonwealth. DEP's site suitability regulations cannot be waived for any reason, and must be designed so that the primary considerations for site selection are the protection of the public health, safety, and the environment.

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[5] "Performance objectives" are regulatory standards established to ensure a required level of performance for the LLRW issue of interest. This phrase is also used by the NRC in its LLRW disposal facility regulations, 10 CFR Part 61, to describe certain required criteria necessary to ensure the proper performance of LLRW disposal facilities.

[6] "Shallow land burial" is frequently interchanged with the term "near-surface disposal," a nomenclature used by the NRC in its 10 CFR 61 disposal regulations. The transposition of these two terms is due to the public view that both essentially describe sites where LLRW is buried near the earth's surface. Modern near surface disposal technology can, but does not necessarily, rely on the natural characteristics of the land itself as the primary barrier to isolate waste.

Public Review of Phase I Regulations

All of the regulations and the LLRW Management Plan developed during Phase I require review by the public through a series of statewide meetings. The Management Board, DPH, and DEP are to hold a minimum of six joint meetings, explain their regulations, take public comment, and incorporate those comments into the final regulations before they are adopted.

Only **after** the Management Plan and all regulations have been promulgated, and advance notice has been given to the public, may the Management Board vote on whether or not to initiate site selection.

Phase II: Site Selection

If the Management Board votes to site an LLRW storage, treatment, or disposal facility within the Commonwealth, Phases II through IV of Chapter 111H would be followed.[7] The timing of activities in some of these phases overlaps.

The Management Board, DEP and the CSCs play the major roles in Phase II. The site selection process follows these chronological steps:

(1) The Management Board issues a report which **maps and screens** the entire state using existing geological data, and eliminates areas of the state that appear to be unable to meet the DEP site selection criteria.

(2) The Management Board next issues a report identifying **possible locations** that are likely to contain one or more candidate sites.

Table 2-1
Minimum Site Suitability Requirements of Chapter 111H

- Sites shall be capable of being characterized, modeled and monitored;
- Sites shall be well drained and free of flooding or frequent ponding;
- Waste management areas of a site shall be outside any 100-year flood plain, coastal high-hazard area or wetland;
- Upstream drainage areas shall be minimized to decrease run-off that could erode or inundate waste management areas;
- Sites shall provide sufficient depth to the water table to prevent groundwater intrusion;
- The hydrogeologic unit used for waste management shall not discharge groundwater to the surface;
- No seismic activity, faulting or volcanism should exist in waste management areas that would significantly affect the site's ability to meet DPH performance objectives;
- No erosion, slumping, landsliding, and other surface geologic processes should exist in waste management areas that would significantly affect the site's ability to meet DPH performance objectives;
- Activities near to waste management areas, including the recovery of natural resources, shall not adversely affect the site's ability to meet DPH performance objectives, or significantly impair the environmental monitoring program;
- Sites shall be located outside of existing or future drinking water sources;
- Sites shall have a reasonable buffer around the waste management area;
- Sites shall not adversely affect any national park, monument, lake shore, endangered species habitat or area protected by the federal Wilderness Act, Wild and Scenic Rivers Act, or National Historic Preservation Act; and
- Sites shall be away from areas or buildings where persons would be at a significantly higher than normal risk of adverse health effects if exposed to a release of radioactive materials due to their age or physical characteristics.

Source: M.G.L. c.111H, Low-Level Radioactive Waste Management Act, 1987.

(3) Public meetings are held in the vicinity of each possible location to receive comments on the possible locations. The Management Board must consider and evaluate **all** comments.

(4) The Management Board's next issuance is a Draft Candidate Site Identification Report, which

[7] If the Management Board determined that an interim or emergency storage facility was needed, it could by-pass many of the siting steps of the law, in order to more quickly identify a centralized emergency storage site. The procedure involved in utilizing interim or emergency storage is described in Chapter 12.

will name between two and five "candidate" sites the Board believes are best able to satisfy the DEP site selection criteria.

(5) The Draft Candidate Site Identification Report must be sent to the Executive Office of Environmental Affairs (EOEA) Secretary, who must implement the public review and comment procedures of the Massachusetts Environmental Policy Act (MEPA)[8] to evaluate whether the report is technically adequate and conforms to the DEP siting criteria. In addition, public meetings must be held in each community containing a candidate site to hear public comments on the report, and the Management Board must consider and evaluate all comments.

(6) The Management Board will ask each community where a candidate site is located to establish a CSC to become involved in the detailed, four-season characterization of each candidate site.

(7) The Management Board must vote to accept the Draft Candidate Site Identification Report and proceed with detailed site characterization, or amend the report and then proceed. Detailed site characterization will include investigations and tests, both on site and in the laboratory, to determine whether each candidate site meets the DEP environmental site suitability criteria.

(8) Following the year-long detailed environmental site review, the Management Board will issue a draft report of the **detailed site characterization** of each candidate site. Public meetings must be held in each community where a candidate site is located, to obtain public review and comment.

(9) The Draft Detailed Site Characterization Report must be transmitted to the EOEA Secretary, for review following the procedures of MEPA. The Secretary must issue a statement evaluating the report's technical adequacy and conformance to the DEP siting criteria.

(10) The Management Board must vote to accept or amend the Draft Detailed Site Characterization Report. If the Board fails to accept or amend the report, it must be set aside, and the siting process initiated again.

(11) If the Management Board votes to accept or modify the Detailed Site Characterization Report, it may select any superior site identified in the report, but only by a two-thirds vote of its members. Upon such a vote, the State will acquire the site.

(12) If a petitioner challenges the siting decision and requests an adjudicatory proceeding, the DEP Commissioner must issue a final decision approving or denying the selection of a superior site.

Phase III: Operator/Technology Selection

While detailed site characterization is being conducted as part of Phase II, the CSCs of each candidate site community interview all potential facility operators that have been certified by the Management Board as meeting the operation selection criteria regulations.

After the superior site is selected by the Management Board, the CSC of that community will choose

[8] The "MEPA" process ensures an open and deliberative review of all environmental impacts so that decisions may be made, and actions taken, to ensure environmental protection during project development, construction, and completion.

the operator and the type of facility (e.g., above-ground or below-ground vaults, for example), which best meets the site and the community's needs.

Phase IV: Facility Approval and Licensing

In this phase, the facility must be licensed by DPH (or the NRC if Massachusetts is not an Agreement State),[9] before construction can begin.

An environmental impact review of the proposed facility must be conducted by the MEPA staff of EOEA, and the final environmental impact report must be accepted before DPH acts on a license application.

DPH will then issue a draft license approval or a draft denial for public comment at public meetings in the site community. When issuing its final license or final denial, DPH must respond in writing to all comments received.

After licensure occurs, the Management Board and the facility operator enter into an operating contract detailing the rights and obligations of all parties. The operating contract will also describe the economic benefits which the "site" community and any "neighboring" communities will receive from the operator. Chapter 111H clearly delineates a range of monetary benefits paid by the facility operator to the site and neighboring communities based upon the volume accepted by the facility, and the length of time between licensure and facility operation. Table 16-1 in Chapter 16 outlines all possible economic benefits available under Chapter 111H.

Phase IV is the period during which the provisions of Massachusetts General Laws c.164, Appendix, sections 3-1 to 3-9 would be implemented, to the extent applicable. This law, adopted by statewide referendum, requires the Legislature to certify that the site and the technology are "superior," after which a question on the approval of the site would be placed before the voters in a statewide referendum.[10]

Phase V: Facility Development, Operation, Closure, and Post-Closure Observation and Maintenance

Upon the issuance of a license for the facility, DPH must establish an environmental monitoring program to ensure an independent monitoring system for the site community. Site construction would be monitored by the Management Board, DPH, and the CSC.

If DPH determines that the facility meets all conditions of the license, and if the Management Board determines that the operator has so far honored its operating contract, the facility may open to accept LLRW. However, DPH may close the facility at any time the agency determines the operation is running improperly.

During the operational period of the facility, which may last 30 to 40 years or more, the operator must honor its contractual obligations to the site community, including economic and social benefits agreed upon during Phase IV. In addition, the operator must pay to the state fees to cover maintenance, monitoring, liability claims, clean-up (if necessary), and costs of stabilizing the site during the institutional control phase after the facility no longer accepts waste. The operator remains responsible for maintaining the facility for

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[9] Please refer to the further explanation of the Agreement State program in section 2.5 of this chapter.

[10] See the discussion of the referendum law on page 2-12 of this chapter.

at least five years after the facility closes.

Phase VI: Institutional Control

The final phase relating to in-state storage, treatment, or disposal facility management is Phase VI, the period when the Management Board must assume responsibility for the site after LLRW ceases to be accepted at the facility, in accordance with federal requirements. The length of the institutional control period is not specifically set in Chapter 111H. However, the law does require that the "institutional control period shall not be less than the minimum time required for any LLRW present at the site to decay to the maximum concentrations above natural background levels permitted to be released" under federal and state law. The impact of that requirement would be the removal from the disposal site of any LLRW containing radioactivity greater than these maximum concentrations. Because of this mandate, the act of "disposing" of LLRW in such a facility is akin to long-term storage.

Other Relevant State Laws

Besides Chapter 111H, provisions of other state laws also affect LLRW management. They include:

- St. 1987 c.549, sections 6 and 7, which directs the Management Board to represent the Commonwealth in negotiating regional agreements for LLRW disposal, and enables the Governor to enter into an agreement with the Nuclear Regulatory Commission to become a limited or full Agreement State.

- Massachusetts General Laws c.111, sections 5M through 5P, which designates DPH as the State's Radiation Control Agency to regulate radioactive materials, LLRW, and machines that emit ionizing and nonionizing radiation.

- Massachusetts General Laws c.21C, which gives DEP authority to regulate toxic, chemical "hazardous waste," including "mixed waste" that contains both radioactive and hazardous components, or exhibits their characteristics. (See Chapter 8 for a detailed discussion of DEP's role in mixed waste management.)

- Massachusetts General Laws c.30, section 62A, the Massachusetts Environmental Policy Act (MEPA), which requires the State to review state-sponsored and state-permitted actions that have major environmental impacts.

- Massachusetts General Laws c.94B, the Hazardous Substances Labeling Act, which authorizes the Commissioner of Public Health to designate certain substances as hazardous and to require labeling in conformance with the federal Hazardous Substance Act.

- Massachusetts General Laws c.149, which empowers DPH to require reports from individuals who manufacture, possess, or use substances that are so hazardous to health that the DPH may regulate their storage in outdoor receptacles.

- Massachusetts General Laws c.21I, the Toxic Use Reduction Act, which sets out a plan for the Commonwealth to reduce the use of toxic chemical materials by 50% by 1997.

- Massachusetts General Laws c.131, section 40, the Wetlands Protection Act, which requires the local Conservation Commission (and DEP, upon appeal) to establish an "order of conditions" for each proposal to remove, drill, dredge, or alter a wetland.

- Massachusetts General Laws c.21, sections 26-53, the Clean Waters Act, which prohibits the discharge of pollutants into waters of the Commonwealth without valid state permits.

- Massachusetts General Laws c.21E, the Massachusetts Oil and Hazardous Material Release Prevention and Response Act, which establishes liability for persons responsible for releases or "threats of releases" of oil or hazardous material.

- Massachusetts General Laws c.149, section 1, which authorizes the Department of Labor and Industries to conduct regular and systematic inspections and investigations of all places of employment.

- Massachusetts General Laws c.81, which authorizes the Massachusetts Department of Highways to regulate activities on the public roads of the Commonwealth. (See Chapter 9 for a detailed discussion of LLRW transportation.)

- Massachusetts General Laws c. 164, Appendix, sections 3-1 to 3-9, the Nuclear Power and Waste Disposal Voter Approval and Legislative Certification Act, which, as noted in the summary of "Phase IV" activities, requires a legislative certification that the site and the technology selected are superior, to be followed by a statewide ballot vote on site approval.[11]

2.4 The Local Role in LLRW Management

Several of the chapters contained in this Management Plan detail various types of local involvement in the management of LLRW. That involvement is primarily in the form of citizen participation, rather than through the enforcement of municipal by-laws or ordinances, which generally are pre-empted by state and federal laws and regulations.

However, local government also plays a significant role in LLRW management activities, particularly if a decision is made to initiate storage, treatment, or disposal facility siting within the Commonwealth.

Chapter 5, the Public Participation chapter of this Plan, describes all the elements of public participation required under Chapter 111H. That chapter discusses public participation in the case of **no siting** of a storage, treatment, or disposal facility within the Commonwealth, as well as the elements of public participation **if siting occurs,** and should be reviewed in connection with the role of local governments in LLRW management.

In addition, Chapters 16 and 17 describe economic impacts to site and neighboring communities, and offer recommendations regarding community compensation and impact payments, including property value protection.

Local Government Involvement

In general, officials of local government -- including the Chief Executive Officer (CEO) (i.e., the city manager, mayor, town manager, or chairman of the Board of Selectmen), the Conservation Commission, the Board of Health, and other officials, are encouraged throughout various LLRW management activities to participate fully in reviewing draft reports and documents, and to supply comments to the Management

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[11] See the discussion of the referendum law on page 2-12 of this chapter.

Board and other state agencies.

If the Management Board determines that a facility must be sited within the Commonwealth, the role of municipal governments is more complicated. Once candidate sites have been identified for additional, detailed environmental study, the official representative of the involved communities becomes the Community Supervisory Committee (CSC).

Involved communities are divided into three categories by Chapter 111H: "site community," "neighboring community," and "affected community." A "site community" is defined as a community in which is located all or any part of any "superior" or final site, as selected by the Management Board. A "neighboring community" is a municipality other than a site community, which according to the census has at least 20% of its population residing within three miles of any superior site. An "affected community" is a municipality other than a site community, which is identified in an environmental impact report as expected to experience "significant impacts" as a result of the location, development, operation, closure, post-closure observation and maintenance, or institutional control of a facility.

Local officials are encouraged to participate in LLRW management planning activities, including discussions with Management Board members and other state officials, involvement in the Public Participation Advisory Committee, and participation at public meetings.

If facility site selection is initiated, three interim reports are issued by the Management Board in connection with the statewide screening of all available lands to identify sites which would require further study and characterization. These reports include the <u>Statewide Mapping and Screening Report</u>, the <u>Possible Locations Report</u>, and the <u>Candidate Sites Identification Report</u>. Thereafter, prior to site selection, the Board issues a <u>Detailed Site Characterization Report</u> evaluating the environmental suitability of each candidate site. At every juncture in the siting process, CEOs of the municipalities named in specific reports must be notified and consulted. The involved CEO may identify other advisors for advice and assistance besides the local citizens appointed to the CSCs. In this manner, the local CEOs can involve numerous other municipal residents and local officials in discussions about facility siting.

<u>Voter Approval of Facility Sites</u>

As noted earlier in this chapter, another state law authorizing citizen authority over LLRW management is considered by some legal authorities and environmental experts to interfere with the authority of local governments involved in the siting process, and to reduce the importance of environmental siting criteria in the siting phase.

This law is Chapter 164, Appendix, sections 3-1 to 3-9, the Nuclear Power and Waste Disposal Voter Approval and Legislative Certification Act of 1982. This statute, passed by referendum, requires voter approval on a statewide ballot for any facility sited in Massachusetts for LLRW storage, disposal, or treatment by incineration (but not other types of treatment), which is not solely for the storage, disposal, or treatment by incineration of waste produced from medical or bio-research applications. It effectively could give the voters of certain, more populated areas of the state, decision-making authority over the actions of those who may live in the site community.

An opinion issued in June, 1986, by the Massachusetts Supreme Judicial Court indicated that the legislative certification and voter approval provisions of the referendum law pertaining to the siting of an LLRW facility could not be constitutionally incorporated into the regulatory structure established by Chapter 111H. The applicability of this law is expected to be challenged.

2.5 A Federal-State Partnership: the Agreement State Program

The Agreement State program of the NRC allows states to take responsibility for the control of one or a combination of five groupings of radioactive materials or radioactive sources described as "agreement materials" in the AEA amendments. These five categories include:

(1) source materials;

(2) special nuclear materials in small quantities;

(3) byproduct materials;

(4) uranium mills and mill tailings defined by the Uranium Mill Tailings Radiation Control Act of 1978;[12] and

(5) LLRW disposal (excluding mill tailings).

Some radioactive materials are not regulated by the NRC, and are therefore not included in the Agreement State program. Examples include Naturally-Occurring and Accelerator-Produced Radioactive Materials (NARM) such as radium and Thallium-67.[13]

To date, 29 states have chosen to become Agreement States, as shown in Table 2-2.

Table 2-2
Agreement States

Alabama	Georgia	Maine[a]	New Mexico	South Carolina
Arizona	Illinois	Maryland	New York	Tennessee
Arkansas	Iowa	Mississippi	North Carolina	Texas
California	Kansas	Nebraska	North Dakota	Utah
Colorado	Kentucky	Nevada	Oregon	Washington
Florida	Louisiana	New Hampshire	Rhode Island	

[a] Maine is the only "Limited" Agreement State.

Source: U.S. Nuclear Regulatory Commission, November, 1993.

Agreement states regulate all users of radioactive materials except for federal facilities, nuclear power plants, and nuclear-powered (university) research reactors, which remain under the control of the NRC. Agreement States receive on-going training and technical support from the NRC.

[12] Because no uranium mills or mill tailing production facilities exist in Massachusetts, this category does not apply to the Commonwealth.

[13] "Naturally-occurring radioactive material" is material that exists naturally in the environment. An example is radium, which is used in watch dials. "Accelerator-produced radioactive material" is produced from product accelerators. An example is Thallium-67, used in medical diagnosis.

For several years, officials of the DPH Radiation Control Program have been Interested in having the State join the Agreement State program. Several of the steps necessary for the Commonwealth to achieve Agreement State status have already been accomplished, as annotated in Table 2-3.

"Full" vs. "Limited" Agreement

By entering into an agreement to regulate a combination of the agreement materials, a state becomes a "full" Agreement State. By agreeing only to license and regulate an LLRW disposal facility, a state becomes a "limited" Agreement State. Among the existing 29 Agreement States, only Maine has opted for "limited" status. The next state expected to be granted Agreement State status -- Pennsylvania -- applied for a limited agreement, but then decided to seek full Agreement status.

To achieve "full" or "limited" agreement authority, a state must have a comprehensive radiation control program staffed with trained experts in radiation and related laws, regulations, and procedures. The program must be found by the NRC to protect the public health, safety, and the environment adequately, and be compatible with the NRC's own regulatory program.

Two sets of "program indicators" are used by the NRC in making this determination. "Category I" indicators encompass program functions that directly relate to a state's ability to protect public health and safety. They include:

Legal authority. State laws must exist and clearly designate a state radiation control program and its authority to promulgate regulations for licensing, inspection, and enforcement.

Table 2-3
Actions Necessary to Become an Agreement State

1. Enactment of a law enabling the State to establish regulations necessary to assume regulatory authority over byproduct, source, and small quantities of special nuclear materials. (Accomplished by section 4 of Chapter 549 of the Acts of 1987)

2. Authorization of the Governor to enter into an agreement with the NRC under section 274 of the Atomic Energy Act to allow Massachusetts to become an Agreement State. (Accomplished by section 7 of Chapter 549 of the Acts of 1987)

3. Adoption of Massachusetts regulations to govern the radioactive materials allowed under the Agreement State program. Approved by the State's Public Health Council in January, 1994.)

4. Hiring the necessary personnel to meet NRC requirements for licensing, inspection, and enforcement.

5. Working informally with NRC to ensure the state program will meet NRC standards.

6. Governor's certification that the State's radiation control program is "adequate to protect public health and safety." (Accomplished by letter from Governor William Weld, July, 1992)

7. NRC's Independent evaluation and finding that the State's program is adequate from a health and safety standpoint and compatible with the NRC regulatory program.

8. If NRC makes a determination that a state program is "adequate" and "compatible," publication of this finding in the Federal Register, authorizing the State to assume regulatory control as an Agreement State.

9. Reviews by the NRC of the State's program, conducted every 18 months (or more frequently, if necessary).

Source: U.S. NRC, "Guidelines for NRC Review of Agreement State Radiation Control Programs," Washington, DC, 1987.

Quality of Emergency Planning. The state radiation control program must have a written plan for responding to such incidents as spills, overexposures, transportation accidents, fires, explosions, etc.

Technical Quality of Licensing Actions. The radiation control program must ensure that license applications contain essential elements which properly describe the radioactive isotopes and quantities to be used, the qualifications of the individuals who will use the radioactive materials, etc. The radiation control program must have procedures for reviewing licenses prior to renewal, to ensure licensee compliance.

Status of Inspection Program. The radiation control program must maintain an inspection program adequate to assess licensee compliance with state regulations and license conditions.

Inspection Frequency. The radiation control program must establish an inspection priority system and base the frequency of inspections on the potential hazards of licensed operations.

Inspectors' Performance and Capability. Inspectors must be competent to evaluate health and safety problems and determine compliance and non-compliance with state regulations.

Response to Actual and Alleged Incidents. The program must be prompt in evaluating the need for on-site investigations and completing investigations.

Enforcement Procedures. Enforcement procedures must be sufficient to provide a substantial deterrent to licensee noncompliance.

"Category II" Indicators, used by NRC to determine a successful Agreement State program, address technical and administrative support for major program functions. They include:

Legal Assistance. Legal staff that is knowledgeable about the radiation control program, its laws and regulations, must be assigned to the program.

Budget. Funds to operate the radiation control program must come from continuous and reliable sources, such as a state's general appropriations, or fees charged licensees. Financial resources must be sufficient to support all program needs, including staff travel for inspection and monitoring, emergency response, and other activities.

Staffing Level. Staffing level must equal approximately 1-1.5 individuals for every 100 licenses in effect (excluding licenses for nuclear power plants, research reactors, and federal facilities).

Licensing and Inspection Procedures. The radiation control program must develop licensing and inspection guides consistent with NRC practice.

Program Costs

The operation of an Agreement State radiation control program is not accomplished without expense. Start-up costs to hire personnel and purchase equipment may require state appropriations, unless other sources of funding are identified, such as fees assessed on radioactive materials users.

The NRC has stated that the Agreement State program is less expensive to radioactive materials licensees, because states do not have to include in their fee structures the costs of all research and development (R&D) related to the use of radioactive materials. Such is the case with the NRC, who by federal law must have licensees absorb the full costs of its expansive R&D programs.

In Massachusetts, the present yearly licensing fees charged by the NRC total over $2.5 million dollars for the approximately 380 radioactive materials licensees who would be regulated by DPH under an Agreement State program (i.e., not including fees paid by the two nuclear powered utility companies or the other excluded licenses). Estimates by DPH of the annual costs to staff an Agreement State program range from $500,000 to $800,000.

These savings have been identified by other states, as well. For example, approximately 970 licensees in Pennsylvania currently pay over $4.7 million in annual fees to the NRC; the Pennsylvania Radiation Control Program has calculated that its annual Agreement State costs will be less than $900,000.

It should also be noted that the savings identified above may diminish if the NRC were to decide to charge each Agreement State a fee to make up some or all of the lost revenue that NRC could have received, were the licensees in those Agreement States regulated by the NRC. No such intention is planned by the NRC at the present time, however.

Most states in the program use a combination of funding sources and recover between 25 and 100% from user fees. Table 2-4 shows a selection of Agreement State program costs and their respective recovery percentages.

The Effect of Agreement State Status on LLRW Management

As has been noted, for more than a decade, the Massachusetts DPH Radiation Control Program has recommended that the Commonwealth become a "full" Agreement State. While informal discussions have occurred between DPH and the NRC, no work was initiated to develop the necessary state regulations until the DPH received authority to implement Agreement State provisions.

That authority was granted in 1987 at the same time as the passage of the legislation creating Chapter 111H. Since then, DPH has produced the necessary regulations for submission to the NRC.

Chapter 111H was adopted by the Legislature under the assumption that Massachusetts would one day become an Agreement State and regulate LLRW facility licensing, monitoring, and inspections. That is why Chapter 111H assigns responsibility to DPH to license any storage, treatment, or disposal facility. Chapter 111H also gives DPH other regulatory power, including the requirement that all LLRW generators implement radioactive materials source and LLRW minimization strategies.

Table 2-4
Cost Recovery in Agreement State Programs

State	Fees charged	% recovery of program costs
Arizona	Yes	75%
California	Yes	95%
Florida	Yes	100%
Kansas	Yes	25%
Kentucky	Yes	43.7%
Louisiana	Yes	80%
Maryland	No	—
Mississippi	Yes	97%
Nebraska	Yes	35%
North Carolina	Yes	27%
New Hampshire	Yes	21%
New Mexico	No	—
Oregon	Yes	81%
South Carolina	Yes	78%
Tennessee	Yes	100%
Texas	Yes	83%
Utah	Yes	25%
Washington	Yes	100%

Source: U.S. Nuclear Regulatory Commission, December, 1989.

If Massachusetts does not become an NRC-authorized Agreement State, the provisions of Chapter 111H which are the responsibility of DPH -- including facility licensing, inspection, and source and waste volume minimization -- will remain the NRC's responsibility.[14] General DPH statutory authority to protect public health would continue to enable DPH to monitor radiation-related activities at the boundary of a licensee's property; the Management Board would continue to be responsible for any decisions regarding siting any in-state facility; and the site community would maintain its responsibilities to select the facility operator and facility technology.

[14] The NRC has a policy encouraging waste minimization by LLRW generators, but it is not mandated as in Chapter 111H. If the State does not become an Agreement State, it is likely that LLRW generators will continue their successful volume minimization efforts, but such efforts may be less than those that could be achieved through a mandatory source and waste volume reduction program implemented by the State.

The status of Massachusetts as an Agreement State or non-Agreement State therefore affects the regulatory control which the State can maintain over LLRW management. Massachusetts as a non-Agreement state has authority to:

- enforce transportation and packaging requirements, which must be consistent with DOT standards;
- license NARM material and determine the requirements for its disposal;
- regulate mixed waste;
- identify sites for storage, treatment, and disposal facilities;
- assist a site community in its selection of a facility operator and facility technology;
- participate in negotiations with the facility operator and the site community regarding compensation and impact payments;
- undertake other activities relating to facility development, operation, closure, and institutional control, as owner of the facility property; and
- review and comment on actions by NRC to license both users of radioactive materials and facilities for storage, treatment, and disposal.

Conversely, in addition to the list of powers cited above, Massachusetts as a "full" Agreement State has the authority to:

- regulate the users of radioactive materials, including licensing the use of specific radionuclides and inspecting the users' facilities, waste generation, packaging, source and waste volume minimization activities, and shipping papers;
- impose mandatory source minimization, volume minimization, and storage for decay requirements;[15] and
- regulate facilities for the storage, treatment, and disposal of LLRW waste, including granting (or denying) licenses, regulating facility operations, closure, institutional control, inspection, monitoring, radiation control and enforcement; and conduct environmental reviews (MEPA) necessary for facility licensing.

2.6 Recommendations on Agreement State Status

Since the passage of the federal Low-Level Radioactive Waste Management Act in 1980, which assigns LLRW disposal responsibilities to all 50 states, increased interest has been demonstrated by some non-authorized states in seeking Agreement State status. Many state officials recognize that the regulation

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[15] Storage for decay is a procedure in which LLRW with a relatively short half-life is held for natural radioactive decay in compliance with applicable federal and state regulations. Following the storage for decay period, the waste can be disposed of as essentially non-radioactive trash.

of LLRW is a serious and controversial public health, environmental, and political issue that demands close and ongoing attention by state inspectors and state policymakers. It is for these general reasons that the Management Board recommends Massachusetts become an Agreement State.

Besides enabling states to control the licensing and monitoring of LLRW disposal facilities, Agreement State authorization offers other benefits. For example, it allows states to establish more stringent radiation protection standards than currently are required by the NRC. In order to become an Agreement State, a state's radiation control program regulations must be compatible with those of the NRC. In some cases, compatibility means the state requirements must be essentially identical to the NRC's. In other areas, however, as long as they meet NRC regulations in "principle," state requirements can be more restrictive.

Table 2-5 lists some general examples of regulatory "equivalence," known as "strict compatibility," versus those where a state can be more flexible (i.e., stringent).

Table 2-5
Compatibility to NRC Regulations

Some areas of "strict compatibility"	Some areas where states may be more restrictive
• Definitions such as "curie," "dose," "rad," and "byproduct material"	• ALARA
• Units of radiation dose	• Personnel monitoring
• Units of radioactivity	• Picking up, receiving, and opening packages
• Dose limits	• Sampling procedures
• Occupational dose limits	• Radiography inspection and maintenance
	• Content of application for disposal facility license
	• Protection of individuals from intrusion into a disposal facility
	• Site suitability for LLRW disposal facility
	• source and LLRW volume minimization

Source: Council of State Governments. "Suggested State Regulations for Control of Radiation." Washington, DC, 1982.

The Issue of "Strict" Compatibility

The issue of what Agreement State regulations were required to be "strictly compatible," or identical verbatim to NRC rules, and what state regulations could be more restrictive, has been brewing between Agreement State officials and the NRC for several years. Many states running Agreement programs have expressed concern regarding NRC's interpretation of its regulations to requirements placed on the states. The Organization of Agreement States (OAS), representing states with such agreements, as well as individual Agreement States, have been communicating their concerns to the NRC since 1989.

Following a letter expressing such concern from the OAS in November, 1989, the NRC directed its staff in October, 1990, to form an interoffice Compatibility Task Force to evaluate compatibility issues. Because the NRC's interoffice task force did not include any participation by Agreement State officials, the OAS established its own Task Force on Compatibility in November, 1990.

The NRC Compatibility Task Force completed its report to the Commission in February, 1991. Among its findings were conclusions that:

- the NRC has "allowed Agreement States to adopt standards or program procedures both more and less restrictive than Commission standards;"
- the NRC developed its compatibility criteria generally without state involvement; and
- the NRC has "seemed to require a high degree of uniformity from Agreement States."

The NRC task force identified three options for Commission consideration. Option 1 would require

strict compatibility (i.e., essentially verbatim) language for such issues as 10 CFR Part 20 regulations on radiation protection standards and principles, on important definitions (such as "dose," "curie," "radiation area," etc.), on licensing procedures, and on LLRW management and disposal. Option 2 would provide strict compatibility for most of the factors identified in Option 1, but would encourage state innovation, and consider local conditions and needs. Option 3 would require strict compatibility "where uniformity was needed to advance specific federal initiatives," but would otherwise allow state innovation, consider local conditions and needs, and recognize the states' needs to provide an equal level of protection for all regulated radiation sources.

The NRC Compatibility Task Force felt that Option 2 was similar to the existing Agreement State program, in which certain requirements had to be essentially identical to the NRC's, and certain areas allowed state flexibility.

The OAS Task Force on Compatibility submitted its report and recommendations to the NRC in March, 1991. It urged NRC to work with Agreement State officials in developing new policies and regulations. In particular, it recommended that a joint NRC/Agreement State committee be established to develop "a compatibility strategy and its application." Such a committee would address the creation of compatibility criteria, and decisions regarding the compatibility aspects of new regulations.

The OAS report also recommended that "more clearly defined criteria" for determining the compatibility of regulations be developed, and that Agreement States should be involved in that activity. The OAS Task Force commented that compatibility should be related to "adequacy" of state programs, and that the burden of justifying a more stringent state standard should not be placed on the Agreement States; rather the burden should be on NRC to demonstrate that any deviation from verbatim equivalence with NRC regulations will have a negative impact on health and safety.

Management Board Comments on Compatibility

The next action on the compatibility issue occurred in December, 1991, when NRC issued a Federal Register notice requesting comments from the public on the compatibility of Agreement States with NRC regulatory programs. The Management Board offered comments in February, 1992. While the Board indicated its support for a "uniform national approach to both safety and health-related radiation matters," it expressed concern regarding the manner in which uniformity has been implemented since the Agreement State enabling law was adopted by Congress in 1959.

The Management Board comments stated that "too much emphasis" has been placed "on identical language, instead of a concentration on the mission of both the NRC and Agreement states: to protect the public health and safety with respect to materials covered by the agreement, and to ensure a basic understanding between the regulators and those being regulated."

The Board urged NRC to narrow its scope of uniformity to allow for consistency between NRC and the states within the basic terms and standards comprising the framework for an Agreement State program, rather than using a comprehensive focus that would require exactness with all elements of a state program. The Board also recommended a complete review of the existing four "divisions" or levels of compatibility, through an "open and deliberative process" that includes state participation. While the Board's comments indicated support for the premise that "certain radiation principles, terminology, signs, and symbols should be identical," it urged far greater flexibility to allow for different state situations. Management Board comments stated:

> "Compatibility should not be judged by the "strict" standard of identical language; rather it should be assessed on the basis of each state's individual plan to achieve the basic radiation protection goals. If a state can meet those goals in a unique manner, it should

not be penalized for failing the current "verbatim" standard.

"The issue of compatibility might best be resolved by using the NRC regulations as a minimum, national standard that must be met by all states, but which could be exceeded, with appropriate justification, depending upon local needs. As long as a state can justify that its regulations provide the necessary level of public health and safety without causing an undue burden on the regulated community, then NRC should find the state's program and regulations "compatible" and "adequate" to protect health and safety."

While the differences of opinion about the compatibility issue are not yet resolved, the NRC appears to have recognized that the states' LLRW management and disposal responsibilities place new, important burdens on state governments, who may need to utilize creative, non-verbatim, rules to achieve success.

Other Benefits of Agreement State Program

While, as noted, the issues of health and safety are the primary reasons for Management Board support of Massachusetts becoming an Agreement State, a secondary reason for support is due to the potential significant annual cost savings that will result to radioactive materials licensees in the state, without a decrease in program implementation and regulatory enforcement. As noted earlier in this chapter, NRC licensees in the Commonwealth who would be regulated by DPH under an Agreeement State program, are presently paying over $2.5 million yearly to the NRC. DPH has calculated that its entire costs to run such a program would be one-fifth to one-third of the NRC's annual costs, or $500,000 to $800,000. The Board believes that DPH can capably administer an Agreement State program for this expenditure, and can recover the full costs from the licensees, as is done in other states.

Agreement State status provides another benefit in its provision that each agreeing state must fulfill a series of requirements that establishes and maintains a radiation control program that is as comprehensive as the NRC regulatory system. The resulting state emphasis on radiation health and safety matters, and the increased accessibility to the radioactive materials users that will result from the availability of state inspectors and state technical assistance programs, are additional reasons to join this program.

This advantage was cited in the results of a study undertaken by the National Governors' Association (NGA) in 1983. The NGA report concluded that experience with the Agreement State program showed that state programs generally respond to verbal and written requests more rapidly than does the NRC; state personnel are more accessible; inspections are more frequent; and there is a greater familiarity and appreciation by program staff for local issues, practices, and expertise.

In 1984, the Massachusetts Special Legislative Commission on Low-Level Radioactive Waste recommended that the State become at least a "limited" Agreement State if an LLRW disposal facility is sited within the Commonwealth. The Commission concluded that the Agreement State program would enable Massachusetts to establish more stringent standards for the protection of public health, safety, and the environment than were required by the NRC.

Agreement State status will give Massachusetts the means to ensure that waste in storage at perhaps 200 licensed users' locations all around the state, after the loss of access to the Barnwell, South Carolina disposal site, will be monitored, inspected, and otherwise regulated to avoid public health or environmental danger.

In July, 1992, Governor William F.Weld submitted a letter to the NRC, officially applying to have the Commonwealth enter the Agreement State program. Final approval of full Agreement State status for Massachusetts is expected sometime in 1994.

2.7 Chapter References

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Chapter 3: Radiation Sources, Health Effects, and Protection Standards

3.1 Introduction

Approximately 450 hospitals, universities, government agencies, biotechnology firms, pharmaceutical companies, and other businesses, including the two utilities with nuclear power plants, are licensed by the U.S. Nuclear Regulatory Commission (NRC) or are registered with the State's Department of Labor and Industries to use radioactive materials in Massachusetts.

These materials are used to produce a wide variety of goods and services. Some of the applications include:

- medical procedures such as diagnostic imaging examinations, radioimmunoassays, diagnosis and treatment of thyroid dysfunction, and cancer diagnosis and treatment;
- university education and research in medicine, materials properties, biotechnology, and other commercial and industrial areas;
- research and development in the biotechnology industry for the treatment and prevention of various diseases and medical dysfunctions;
- confirmation of theories in numerous fields, including scientific and medical investigations that support Nobel Prize considerations;
- Industrial radiography of pressure vessel and other structural welds;
- other commercial uses such as level measurement, thickness measurement, moisture and density analysis, and quality control;
- commercial and domestic applications in smoke detectors and exit signs;
- commercial and academic analysis such as gas chromatography; and
- the production of electricity from nuclear power plants.

Low-level radioactive waste (LLRW) is the by-product of the use of radioactive materials for these purposes. Equipment and materials used in these institutions may become contaminated with low concentrations of radioactive elements and compounds, or, in areas of neutron generation, may become "activated." Materials that become radioactive waste in this manner include protective clothing such as gloves and coveralls; metal components and tools; filters and filter media; sludges; soil and building rubble from decommissioning and remediation activities; research test tubes and other apparatus; animal carcasses; residual liquids and other materials from the diagnosis and treatment of patients; and hospital

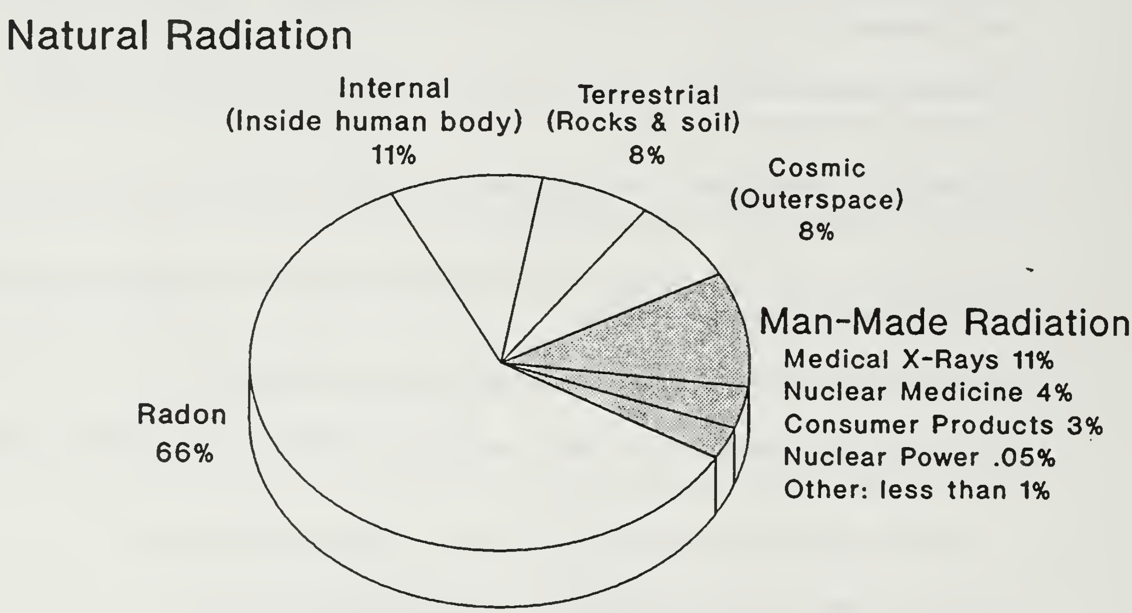
patient bandages and bedding.

This chapter summarizes some basic concepts about radiation and radioactivity. It also describes the differences of opinions among scientists and others about the health effects from radiation exposure, and summarizes radiation protection standards designed to protect the public, workers in locations where radioactive materials are used, and the environment.

3.2 Radiation and its Sources in the Environment

Radiation is a form of energy that passes through space, air, or other matter in a manner similar to waves or particles. The general term "radiation" covers all forms of radiant energy, including light, radio waves, infrared energy, and microwaves. However, in contrast to these types of radiation, the type of radiant energy associated with radioactive materials is known as "ionizing" radiation.

Figure 3-A
Percentages of Radiation Exposures from Natural and Man-Made Sources



Source: National Council on Radiation Protection and Measurements.

Ionizing radiation may be visualized as energized particles or waves of energy that cannot be detected by our five senses. Ionizing radiation is of concern because it can "ionize" (impart electrical charge to stable atoms), often causing a change in the chemical structure of living tissue and other matter. In the remainder of this document, the discussion of radiation and its effects refers to ionizing radiation, only.

It is understood that radiation always has been present in the universe; it exists all around us. We receive doses of radiation from such natural materials as granite and natural gas, which contain small amounts of naturally occurring radioactive elements. Living or working in stone or brick structures increases our exposure over occupying wooden buildings. This is because the brick or stone may often contain radionuclides,[1] which emit penetrating radiation or radioactive radon gas, which can be subsequently inhaled. Rocks, soil, and groundwater contain various quantities of radioactive materials, some which are gases that can be released into the air (e.g. radon gas). Concentrations of radioactive gases can increase inside buildings due to the tendency for buildings to draw gases from underlying soil and, less significantly, the use of groundwater from wells. An estimated 120 curies of radon is released from the soils of the United States each year.

We are also exposed daily to cosmic radiation from the sun and the stars. The sun produces Carbon-14 and Hydrogen-3 in the air and ocean. We receive an extra dose of radiation during airplane flights because the planes often fly above much of the earth's protective atmospheric screen. Naturally occurring radioactivity exist in plants, animals, and the human body from sources that have existed on earth since its formation. For example, our bodies contain naturally occurring radioactive potassium (in bone) and carbon (in body tissues). Many foods we eat contain radionuclides, including milk (Potassium-40).

This natural, non-man-made radiation accounts for more than 82% of the radiation exposure we receive. The remaining 18% of our radiation exposure comes from man-made radiation sources. (See Figure 3-A). About 15% of the total is from the use of medical x-rays, radioactive materials used to diagnose and treat disease, and dental x-rays. The remainder of man-made exposure comes from nuclear powered electric plants (.05%), nuclear weapons testing and other uses of radioactive materials (1%), and minute emissions from certain consumer products such as smoke detectors, camping lanterns, self-illuminating watches and color television sets (3%). Table 3-1 illustrates the variety of consumer products which emit radiation, in use in our daily lives. The radiation sources in "Group 1" of Table 3-1 involve large numbers of people and relatively large dose equivalents. They include cigarette smoke and drinking water supplies.

Therefore, lifestyle, geographical location, career and other factors affect the total annual radiation exposure received. Based on these factors, it is possible to estimate one's annual dose of radiation. Figure 3-B shows an example of possible doses from common radiation sources. Persons living in the United States receive, on average, an annual whole body dose[2] of about 360 millirems from both natural and man-made radiation. However, the dose rate varies with geographic location, elevation, and other local factors. For example, as elevation increases, the dose increases, approximately 1 millirem every 100 feet. In Denver, which is about a mile above sea-level, the background dose is therefore substantially higher than at the Management Board's office on the ninth floor of 100 Cambridge Street in Boston.

Three Main Forms of Radiation

The three principal forms of radiation from radioactive materials -- alpha, beta, and gamma -- have differing physical properties, and therefore cause different effects from their exposure. Alpha and beta radiation can be characterized as tiny, fast-moving particles. Gamma radiation can be visualized as having no mass, like light or radio waves.

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[1] A "radionuclide" or "nuclide" is an atom which releases radiation as it spontaneously disintegrates, or "decays."

[2] "Whole body dose" is to be interpreted to mean "effective dose equivalent" wherever it appears in this Plan. The former term is used in many regulations and documents cited herein, and is retained in the text for consistency with these documents. The latter term represents recent changes in expressing dose.

Table 3-1 Radiation Exposure of the U.S. Population from Consumer Products Arranged in Groups in Accordance With Their Significance			
Source	**Number of people exposed**	**Average annual effective dose equivalent to the U.S. population (Mrem)**	**Annual collective effective population dose equivalent (person - Rem)**
Group I– involves many people and the dose equivalent is relatively large			
Tobacco products	50,000,000	X[a]	X[a]
Domestic water supplies	230,000,000	1.0-6.0	230,000-1,400,000
Building materials	120,000,000	3-5	840,000
Mining and agricultural products	200,000,000	<1.0	200,000
Combustible fuels			
Coal	230,000,000	0.03-0.3	8,000-70,000
Natural gas heaters	16,000,000	0.12	29,000
Natural gas cooking ranges	125,000,000	0.2	50,000
Dental prostheses	45,000,000	0.014	3,000
Ophthalmic glass	50,000,000	<0.1	<20,000
Group II– involves many people but the dose equivalent is relatively small or is limited to a very small portion of the body			
Television receivers	230,000,000	<<1.0	<<230,000
Video display terminals	50,000,000	<<1.0	<<50,000
Radioluminous products			
Watches and clocks	15,000,000-20,000,000	0.001-0.005	1,500
Airport luggage inspection systems	30,000,000	0.00027	60
Gas and aerosol detectors	100,000,000	0.003	800
Highway and road construction materials	5,000,000	0.08	20,000
Aircraft transport of radioactive materials	14,000,000	0.013	3,000
Spark gap irradiators and electron tubes	230,000,000	0.014	1,000
Thorium products			
Fluorescent lamp starters	50,000,000	0.00004	<1.0
Gas mantles	50,000,000	0.04	3,600
Group III– involves relatively few people and the dose equivalent is small			
Thorium Products			
Tungsten welding rods	300,000	0.02	5,000
Check sources	800,000	<0.004	<800
Rounded Total		6.0-13.0	1,200,000-2,900,000

[a] Data necessary to convert the dose to the segmental bifurcations of the bronchial epithelium (estimated at 16 rem/y for the average cigarette smoker) to an effective dose equivalent are not available.

Source: National Council on Radiation Protection and Measurements. Ionizing Radiation Experience of the Population of the United States. Bethesda, MD, 1987.

Alpha particles consist of two protons and two neutrons, or the equivalent of a helium atom nucleus. They are the least penetrating. A sheet of paper can stop alpha radiation; so too does the outer layer of

dead cells in human skin, as is illustrated in Figure 3-C. However, alpha radiation can damage live body cells if the radionuclide which emits alpha particles gets into the body through air, food, water, etc.

A more penetrating type of radiation is beta radiation. The ability of beta particles to penetrate materials depends upon their energy. Some high energy beta particles can penetrate skin and cause damage to living cells. These can travel several feet in air, and can be shielded effectively by small thicknesses of solid material, such as a sheet of aluminum one millimeter thick. Like alpha radiation, beta radiation can affect live cells if taken into the body. In addition, radionuclides that emit high energy beta radiation can reach live cells of surface organs if placed in close proximity to the skin or eyes, for example.

Figure 3-B
Calculating an Individual's Annual Radiation Exposure
Possible Doses from Common Radiation Sources[a]

Location, Career and Lifestyle Affect Annual Radiation Exposure	Millirem
Where a person lives	
Natural background radiation from external sources - Boston	65
Home construction materials (stone, concrete, masonry)	7
Radon (U.S. average)	200
What one breathes, eats and drinks	
Food, water, air (U.S. average)	24
Fallout from world-wide weapons testing	1
Living Habits	
Chest x-ray[b]	20
Airplane travel[c]	2
Watching television 4 hours/day (at .15 mrem/hour)	0.6
Using computer with video display terminal	<1
Sleeping with partner, add 0.1 mrem	0.1
Cooking with natural gas, add 6 mrem	6
Smoke detectors (type made with Americium - 241)	0.6
Total annual dose for this example	327.3
U.S. annual average dose	360

[a] Doses are estimates only, and vary at any given time.
[b] The U.S. average annual dose from medical and dental x-rays and other medical treatment is 50 millirem. One chest x-ray is 20 millirem.
[c] Assumes one-way coast-to-coast flight, at 36,000 feet.

Sources: U.S. Environmental Protection Agency and U.S. Department of Energy.

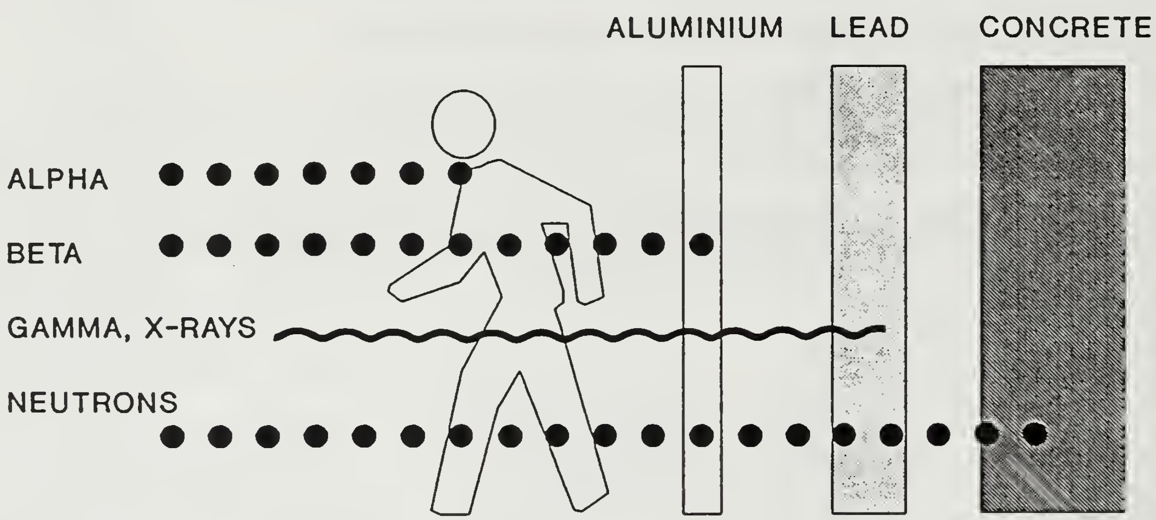
Gamma radiation has the greatest penetrating power, and can completely penetrate and damage all body organs. Sources of gamma radiation outside the body can be shielded to provide protection. It is often necessary to use several inches of lead, steel, or concrete to shield effectively against gamma radiation. The thickness needed depends upon the shielding material selected, and the energy and intensity of the gamma radiation. Radionuclides that emit gamma radiation can damage live cells from outside the body, or within.

Alpha particles, beta particles, and gamma radiation are the principle forms of radiation of concern. Neutrons are another very common nuclear particle. Although not of concern for most purposes under

discussion in this document, they are described only briefly here.

Neutrons are particles that are normally locked within the nucleus of atoms and are similar in mass to protons. They carry no charge, can travel great distances in air, and are very penetrating. Their interaction with other atomic particles or atoms can result in significant radiation emissions and biological damage. However, there are no significant spontaneous neutron emitters, and therefore, they are generally of concern only to certain radiation workers. Since they are generated primarily from fission and from bombardment of nuclei with projectiles, they are normally present only around operating nuclear facilities such as reactors and particle accelerators. Neutrons are typically shielded or attenuated with high concentration hydrogen-bearing materials, such as water.

Figure 3-C
Penetrating Powers of the Types of Radiation



Source: From "Radiation -- a fact of life" pamphlet of the International Atomic Energy Agency, March, 1989.

As can be inferred from the information provided above, radiation exposure can occur from both internal and external sources of radiation. Sources that are inhaled, ingested, or absorbed through the skin will be in such close proximity to body cells that damage to the cells can occur, even though the radiation type may be relatively low in energy or not very penetrating. Limiting the intake of radioactive materials is the principal mechanism in limiting internal exposure. Regulations and standards that protect workers and the public from internal radiation exposure have been established, and are discussed later.

Individuals can be protected from external sources of radiation, even very energetic and penetrating types, through the application of the three concepts of time, shielding, and distance. Since the amount of exposure is a function of the time to which one is exposed to a source of radiation, limiting the time of exposure to the source will reduce the dose of radiation incident on the person. Shielding the source of radiation from the potential human receptor will also effectively limit or eliminate the amount of exposure received by the receptor.

Finally, increasing the distance from the radiation source is a very effective way of reducing the incidence of radiation on the body from external radiation sources, since the intensity of the radiation at a

location varies inversely with the square of the distance from a "point source" or very small area radiation source. For example, the radiation incident on a body from a small source at a distance of 10 feet from the source is $1/10^2$, or 1/100, less than at one foot from the source.

3.3 Radioactivity

Each of the 92 natural elements that comprise all matter[3] is made up of several types of atoms, called isotopes. Each Isotope contains a different central core, or "nucleus," of "heavy" particles known as protons and neutrons. For example, hydrogen, the lightest natural element (atomic number 1), has three different isotopes (Figure 3-D):

(1) hydrogen (single proton in the nucleus)

(2) deuterium (one proton and one neutron in the nucleus), and

(3) tritium (one proton and two neutrons in the nucleus)

Uranium, the heaviest natural element (atomic number 92), has several isotopes. For example, Uranium-235 has a nucleus containing 92 protons and 143 neutrons, while Uranium-238 has a nucleus containing 92 protons and 146 neutrons.

An isotope is "radioactive" if it changes from one atomic form to another through a spontaneous disintegration or "decay" of the nucleus. As it decays, it releases energy in the form of subatomic particles or electromagnetic rays (e.g., "alpha" and " beta" particles or "gamma" rays). A "radionuclide" or "nuclide" is an atom that spontaneously produces "radiation" in these and other forms.

Each radionuclide decays at a different rate. The decay process is measured in terms of the "half-life," or the length of time in which half of the radioactive atoms will decay. The quantity of a radioactive substance can be measured by the number of nuclear disintegrations per unit of time. As radionuclides decay, they eventually become stable, non-radioactive nuclides.

Therefore, the radioactivity and the potential radiation hazard from a radioactive material decreases with time. If a radioactive material is allowed to decay for 10 half-lives, the number of atoms of that radioactive species remaining will be about 1024 times less than the original number. For example, Iodine-123, which is used to diagnose thyroid conditions, has a half-life of 13.3 hours. After 133 hours (10 half-lives), the Iodine-123 remaining would be less than 1/1000th of the original amount and after 266 hours (20 half-lives) the amount remaining would be less than one millionth of the original amount.

The transient nature of radioactive materials and the phenomenon of nuclear decay can be illustrated by describing the decay of two other common radionuclides in a slightly different way, and by use of a more familiar comparison. One of the most abundant radionuclides in the Massachusetts LLRW stream is tritium (Hydrogen-3), which has a half-life of 12.3 years. One thousand atoms of tritium would decay to 500 atoms of tritium after 12.3 years, and to 250 atoms of tritium after 24.6 years (two half-lives) and so on. In contrast, Carbon-14 has a half-life of 5,700 years. It is produced in minuscule quantities by man in comparison to the amount produced naturally in the atmosphere. One thousand atoms of Carbon-14 would decay to 500 Carbon-14 atoms, on average, in 5,700 years.

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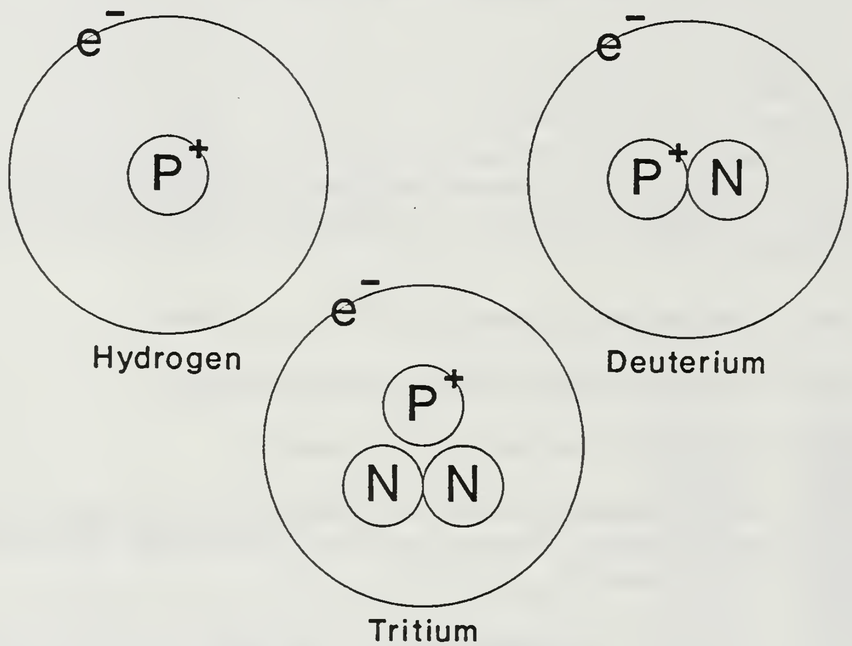
[3] There are currently 106 elements, of which 92 are found in nature, and 14 are man-made.

Figure 3-D
The Three Isotopes of Hydrogen



Source: Massachusetts Low-Level Radioactive Waste Management Board.

Any long-lived radionuclide, like Carbon-14, can be compared to a slowly rotting log. Any short-lived radioactive isotope, like tritium, can be compared to a rapidly burning log. Both are decomposing. The rotting log will take much longer to decompose, and will remain cool, while the burning log will give off high energy in the form of heat and will very quickly decompose, so as not to be a threat at all.

The half-lives of radioactive isotopes range from a fraction of a second to billions of years. Uranium is a naturally occurring radioactive element found in the earth's crust. This mineral is only slightly radioactive because its half-lives are extremely long: for the uranium-235 Isotope, the half-life is 704 million years; for the uranium-238 isotope, its half-life is 4.47 billion years. Although the earth is billions of years old, we are still able to find uranium because it takes so long to decay. As uranium decays, it produces other radioactive isotopes which, in turn, decay. Radium and radon are elements created during this decay process. This "decay chain" eventually results in a non-radioactive, stable isotope of lead.

Both naturally-occurring and man-made radionuclides are found in Massachusetts LLRW.[4] The man-made radionuclides are produced in nuclear reactors or by particle accelerators by bombarding the nuclei of stable or radioactive atoms with different particles, such as protons and neutrons. The specific

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[4] LLRW can contain Naturally Occurring Radioactive Material (NORM), which is radioactive material that has a natural source. LLRW can also contain Naturally Occurring and Accelerator-produced Radioactive Material (NARM), which includes both "discrete" material (small-volume, high-activity material produced in a cyclotron or other type of accelerator, such as radium needles); and "diffuse" material (generally lower-activity radium-contaminated soils or other materials in which radium or other naturally occurring materials exist). The NRC does not regulate NORM or NARM; it is regulated separately by the State.

kinds of radionuclides found in LLRW generated in Massachusetts are discussed in Chapter 4.

3.4 Measures of Radioactivity and Radiation

The mass or amount of a radionuclide can be represented in grams, kilograms, pounds, or other mass or weight units. However, these measures do not provide a convenient measure of the quantity of radiation emitted. Therefore, other units of measure have been devised to express the phenomena of nuclear disintegration and radiation.

Units describing the quantity of a radionuclide in terms of radioactivity include:

Activity is the rate of disintegration or decay of radioactive material.

Curie (Ci) is a unit of activity and represents the quantity of any radionuclide that undergoes 37 billion (3.7×10^{10}) disintegrations per second.

Millicurie (mCi) is one thousandth of a curie or 3.7×10^7 disintegrations per second.

Microcurie (Uci) is one millionth of a curie or 3.7×10^4 disintegrations per second.

Nanocurie (nCi) is one billionth of a curie, or 3.7×10^1 disintegrations per second.

Picocurie (pCi) is one trillionth of a curie, or 3.7×10^{-2} disintegrations per second.

Becquerel (Bq), the International unit of activity, is analogous to the curie. One becquerel = 1 decay per second = 2.7×10^{-11} Ci.

Working level (WL) is a special unit of radioactivity used just to measure radon. It is equal to any combination of short-lived Radon-222 decay products in one liter of air which results in alpha particles discharging 1.3×10^5 million electron volts (MeV) of alpha particle energy.

The curie or the becquerel is a measure of the number of disintegrations per unit of time (seconds, minutes, etc.) and does not necessarily relate to the number of particles or type of radiation given off per unit of time.[5]

Units of "dose" measure the amount of energy emitted in the form of "radiation" absorbed by people, animals or other receptors. Terms and units of radiation dose and exposure include:

Rad (rad) is a "radiation absorbed dose," and measures a specified amount of radiation energy per gram of material such as living tissue. In the case of x-rays, gamma rays, and some beta particles, the rad equals the rem.

Gray (Gy) is the international unit of absorbed dose. (100 rads = 1 Gy).

Rem (rem) is the unit of measurement of any of the quantities of "dose equivalent." The dose

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[5] Shapiro, J. Radiation Protection: A Guide for Scientists and Physicians. Harvard University Press, Cambridge, MA, 1972.

equivalent in rems is equal to the absorbed dose in rads multiplied by a "quality factor" to account for biological reactions to radiation based upon the type of radiation and other factors. In the case of alpha particles, a rem equals 20 times the rad. (The biological effect of this radiation is dependent upon the amount of energy absorbed, and on the type of radiation involved. X-rays, for example, which hit an occasional atom along their penetration route, are considered 20 times less damaging than alpha particles.)

Millirem (mrem) is used to count the exposure of low radiation levels, and equals one thousandth of a rem.

Sievert (Sv) is the international unit of dose equivalent. One sievert = 100 rem.

Absorbed dose means the amount of energy imparted by ionizing radiation per unit mass of irradiated material.

Dose equivalent means the product of the absorbed dose in tissue, quality factor,[6] and all other necessary modifying factors at the location of interest. (See "Rem" below)

Deep-dose equivalent, which applies to external whole body exposure, is the dose equivalent at a tissue depth of 1 centimeter (1000mg/cm^2).

Committed dose equivalent means the dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material during the 50 year period following the intake.

Effective dose equivalent is the sum of the products of the dose equivalent to the organ or tissue and the weighting factors applicable to each of the body organs or tissues that are irradiated.

Committed effective dose equivalent is the sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to the organs or tissues.

Total effective dose equivalent means the sum of the deep-dose equivalent (for external exposures) and the committed dose equivalent (for internal exposures).

Shallow-dose equivalent, which applies to external exposure of the skin or an extremity, is taken as the dose equivalent at a tissue depth of 0.007 cm (7gm/cm^2) averaged over an area of 1 square centimeter.

Other measurements of radiation dose and exposure are:

Roentgen (R) measures the amount of energy lost in air by the passage of gamma or x-rays.

Person-rem measures the total radiation dose received by a whole population. (= number of people in population group x the average radiation dose in rems)

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[6] As noted, quality factors adjust an absorbed dose of radiation to account for the relative biological effectiveness of the different types of radiation. Alpha particles have a quality factor of 20; beta particles and gamma rays have a quality factor of 1.

3.5 Radiation Health Effects

Because Ionizing radiation can damage living cells that can result in sickness, Injury or death, it is important to limit the amount of exposure. Cell damage effects can range from none, to radiation sickness, to genetic effects, to death. For these reasons, limits are placed on radiation exposure. Packaging, storage, transportation, and disposal standards have been established by agencies of the federal government to ensure that little or no public exposure occurs from the use of radioactive materials.

History of Radiation Health Effects

Shortly after the discovery of x-rays by Wilhelm Roentgen in 1896, scientists realized that large doses of ionizing radiation can result in sickness and/or injury. The early workers on Roentgen's x-ray machinery checked the output of the x-ray tubes by exposing themselves to the radiation emitted, and then measuring the time required to irritate their skin. Over 300 of the workers later died from diseases resulting from their large-dose exposures.

In spite of this awareness of tissue damage, hazardous practices continued. One of the most publicized is the occurrence of bone cancer and other diseases incurred by young women who worked for the Radium Luminous Materials Company in New Jersey between 1915 and 1935. Their job was to paint watch dials and other products with a mixture of radium and zinc sulphide. The workers moistened their brush tips by sticking them in their mouths.

In another example, 14,000 British patients intentionally were treated with large x-ray doses ranging between 250 and 2,750 rads for a spinal disease known as ankylosing spondylitis, and developed excessive amounts of leukemia, bone, and stomach cancers.

The medical histories of the survivors of the Hiroshima and Nagasaki bombings in World War II have provided comprehensive information on the health effects of large doses of radiation on large human populations. Within three years after the bombings, an excess of leukemia was noted in survivors, and monitoring of these individuals since that time has identified excesses of numerous other cancers including thyroid, bone, stomach, breast, and lung cancers.

More recently, another group of persons is being monitored as a result of their exposure from the April 26, 1986, explosion at the Chernobyl Nuclear Power Plant in the former Soviet Union. Estimates are that up to 24,000 people from among the 116,000 evacuated from a 19-mile radius around the plant received radiation doses of 45 rem, and about 4,000 of that number received an average of 200 rem. These radiation doses are on the less serious end of the severe health effects estimated from whole body radiation, which are shown in Table 3-2. Their impact over time will be evaluated as this exposed group is monitored many years Into the future.

Categories of Health Effects

Although even very small doses of radiation are known to damage living cells, the ultimate health impact of that damage is not as well understood or universally agreed upon. The degree and effect of possible damage may be influenced by such factors as body size, age, varying sensitivities of body tissues and organs, long latency periods for effects to develop, and the impact of natural radiation exposure. In addition, other environmental factors, such as hazardous chemicals, cause similar biological effects, making it difficult to establish specific cause-and-effect relationships.

Radiation effects on the human body fall into two main categories: "somatic," i.e., damage to body tissue, and "genetic," meaning damage to hereditary characteristics. The main somatic effect Is cancer.

The somatic effects of radiation apply to various body organs and tissue to different degrees. The blood-forming tissue and the gastro-intestinal tract are more susceptible to incurring somatic damage. Internal radiation exposure is of concern because a radionuclide chemically behaves like a non-radioactive atom, and has an affinity for particular organs. Intakes of Strontium-90 deposit in the bone; Iodine-129 and Iodine-131 deposit mainly in the thyroid; and Radon-222 or Krypton-85 gases affect the lungs.

Table 3-2
Severe Health Effects Estimated from Whole Body Radiation

Dose (millirems)	Dose (rems)	Health Effect
5,000-20,000	5-20	Possible late effect; possible chromosomal aberrations
25,000-100,000	25-100	Blood changes
>50,000	>50	Temporary sterility in males (>100rem = 1 year duration)
100,000	100	Double the incidence of genetic defects which is normally expected
100,000-200,000	100-200	Malaise, vomiting, diarrhea, and tiredness in a few hours; reduction in infection resistance, possible bone growth retardation in children.
200,000-300,000	200-300	Serious radiation sickness; bone marrow syndrome; hemorrhage; $LD_{10-35/30}$
>300,000	>300	Permanent sterility in females
300,000-400,000	300-400	Resulting loss of blood defenses and vascular integrity; electrolyte imbalance; marrow/intestine destruction; $LD_{60-95/30}$
400,000-1,000,000	400-1,000	Acute illness, early death; $LD_{100/10}$
1,000,000-5,000,000	1,000-5,000	Acute illness; early death in days; intestinal syndrome $LD_{100/10}$
>5,000,000	>5,000	Acute illness; death, early death in hours to days; central nervous syndrome; $LD_{100/2}$

*Lethal dose to percentage of the population in number of days (for example, $LD_{10-35/30}$ = lethal dose in 10-35% of the population in 30 days.

Source: U.S. Congress, Office of Technology Assessment. Partnerships Under Pressure: Managing Commercial Low-Level Radioactive Waste. OTA-O-426. U.S. Government Printing Office, Washington, DC, November, 1989.

A major genetic effect of radiation includes transmitted birth defects, such as mental retardation. Genetic damage results from whole chromosome damage, in which chromosomes may break or change, causing a rearrangement that impairs the chromosome's function. Genetic damage causes gene mutation, destroying the gene's reproductive abilities, or creating malfunctions such as retardation.

Biological damage from an absorbed dose of radiation is measured as the "dose equivalent." The dose equivalent involves several dependent factors, including: the kind of radiation; the dose received; the half-life; the rate of exposure; the sensitivity of the organ exposed; and the age and health of the individual. A baby developing in-utero is more likely to incur serious damage than an adult exposed to the same level of radiation.

The dose equivalent also is impacted by the way the radionuclide is taken into the body. For example, certain oxide compounds containing heavy elements, if ingested, would be eliminated rapidly by the body's natural processes. But if inhaled, they could lodge in the lungs and remain in the body for a long period of time. Some non-radioactive elements, such as hydrogen, carbon, oxygen, nitrogen, sodium or chlorine, are absorbed by the body, but are also eliminated fairly soon through normal body processes.

The same body chemistry applies to radioactive isotopes of these elements, such as tritium and Carbon-14, which are rapidly eliminated. Therefore, the "effective" half-life of a radioactive substance in the body is the combination of the radioactive half-life and the biological half-life. For example, tritium, a radionuclide in extensive use in life science research, has an effective half-life in the body of 11.97 days, whereas its radioactive half-life is 12.3 years.

Radiation Health Effects Models

Several models for predicting the effects of low-dose radiation are used by the scientific community. Three are illustrated in Figure 3-E. The "linear no-threshold" model shown as line (a) incorporates two assumptions: (1) there is no threshold level below which radiation has no carcinogenic effect, and (2) the effects of radiation at low doses are directly proportional to the effects at high dose levels. The "linear quadratic" hypothesis shown as line (b) assumes that the effects of radiation are proportionately lower at low doses than at high doses, since cells may be able to repair themselves more readily at low doses.

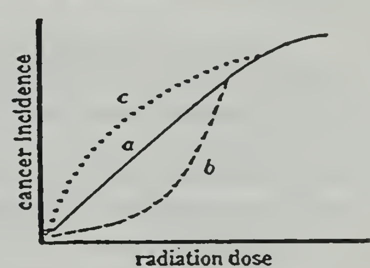
A third model, the "low-dose, higher response" model, shown as line (c), assumes that the effects of radiation at low doses is possibly ten times higher than is predicted by the linear no-threshold model. Another model, not shown in Figure 3-E, assumes a threshold below which the risk is effectively zero. Attempts to prove conclusively that any one theory is correct have been frustrated by the fact that the postulated effects are small and not easy to identify.

Ionizing radiation, from any source, is known to be a carcinogen at high doses and this effect cannot be excluded at very low-doses (doses within normal variations in background radiation). Regulatory conservatism has resulted in adoption of a model that assumes carcinogenic effects will occur at these very low doses.

Figure 3-E
Radiation Dose Models

Dose Response Curves

a = linear no-threshold hypothesis
b = linear quadratic hypothesis
c = low-dose, higher-response hypothesis



x = Available data is plotted on the graph and then a straight line is drawn to zero.
y = The curves gradually level off and then decrease at high doses as a result of more cells dying than becoming damaged.
The curves eventually level off and then decrease at high doses of radiation since more cells die than become cancerous.

Source: Adapted from U.S. Department of Health, Education and Welfare, Report of the Interagency Task Force on the Health Effects of Ionizing Radiation, June, 1979.

Low-Dose Health Studies

These models are largely based upon data from the Japanese atomic bomb survivor studies, which provide data on a large population exposed to high radiation doses. The models project that health effects occur at low doses, but these effects are based on extrapolation of the effects at higher doses. However, national and international standards-setting committees constantly review other radiation health effects data, including low-dose studies.

Numerous statistical studies that attempt to correlate health effects with exposure to small doses have been completed, yet many studies contradict one-another. For example, the Massachusetts Department of Public Health (DPH) issued a study in 1987 suggesting a relationship between excessive numbers of leukemia cases among adult males in Plymouth and four coastal towns north of Plymouth. That study

asserted that radioactive gases released routinely from the Plymouth nuclear power plant into the atmosphere,[7] were returned to the Plymouth/coastal area because of the meteorological patterns in the region, thus causing the increased cancers.

The DPH assertions were contradicted by a later study of the same data conducted by an epidemiological consulting firm, hired by Boston Edison, the operator of the Plymouth power station. One point of the second study argued that emissions from Pilgrim would not have caused an increased cancer rate in only a <u>portion</u> of the Plymouth-area population. The study suggested that it would more likely affect <u>both</u> adult men and women alike. The DPH study was also contradicted by a study conducted by the National Cancer Institute.

Other studies, when compared to one another, also differ with respect to the health effects of small amounts of radiation exposure. One such body of data includes the study of workers who may be exposed to radiation in their occupations. These epidemiological studies are of particular interest because of the relatively large exposed populations and the good records available on individual exposures to low-level radiation. Although some of these radiation worker studies have reported a statistical correlation between low-dose exposure and different illnesses (various cancers, in particular),[8] others have not revealed any statistically significant causal relationship.[9]

Another approach to assessing the impacts of low-dose radiation has been to examine the differences in disease rates among populations exposed to different amounts of background radiation.[10] Although these studies have typically revealed increased chromosomal aberrations in those groups exposed to the higher background levels, the studies have failed to establish any increased incidence of radiation-related disease among the more highly exposed populations. These studies have been conducted throughout the world, and have compared large population groups who possess similar traits, except for their substantial differences in exposure to radiation from natural background sources.

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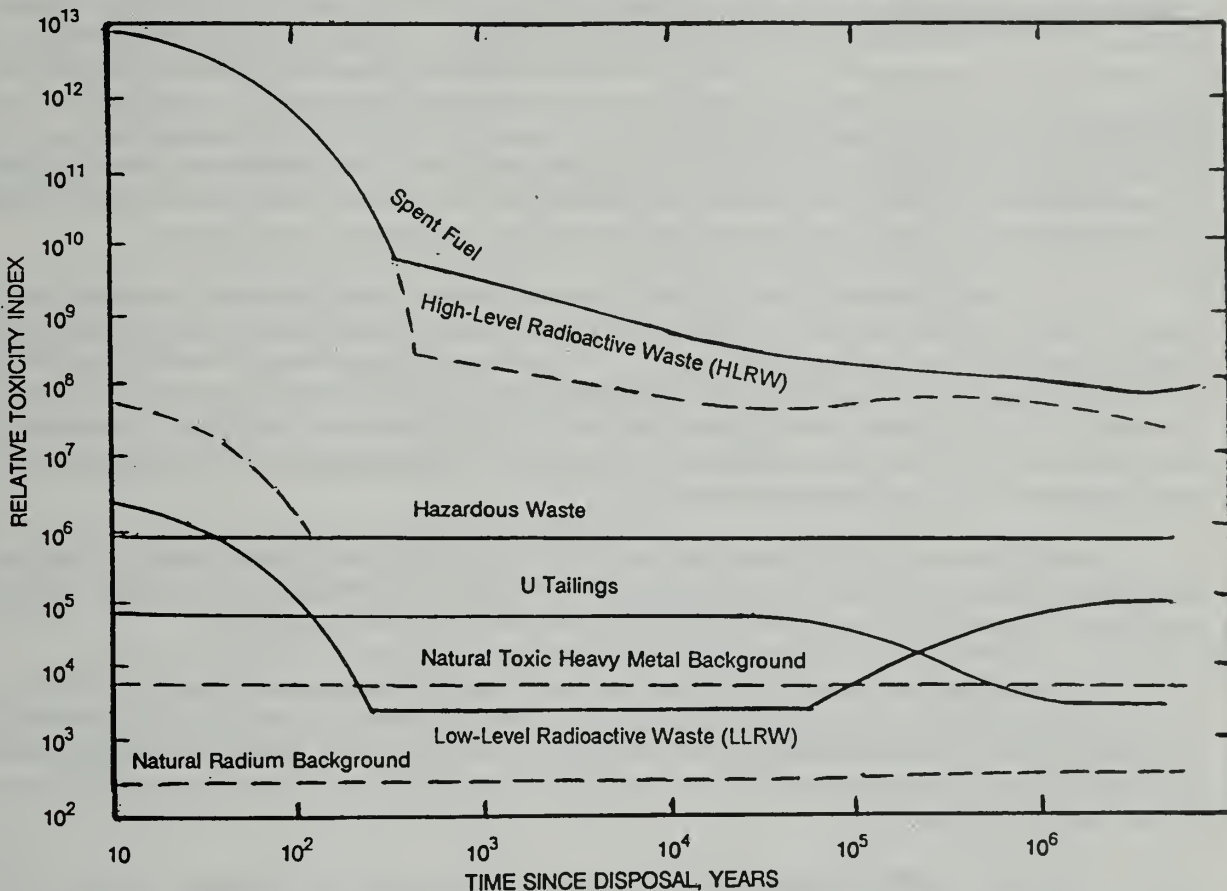
[7] NRC regulations (10 CFR Part 20), allow certain quantities of radioactive gases, most which have short half-lives, to be released to the atmosphere with other air emissions.

[8] For example, several studies of radiation workers in the United States and Great Britain have reported statistical correlations between worker exposures and various health effects, including leukemia in the offspring of men exposed to relatively low doses. [M.J. Gardner and others] In another example, a recent study by S. Wing and others of male workers at DOE's Oak Ridge National Laboratories showed that the employees have a greater rate of leukemia deaths than males in the overall population, possibly as a result of low doses of radiation. This study's results differed from earlier examinations of the same group. Researchers involved in the Wing study concluded that the extra seven years of follow-up data they reviewed may have been the significant variable in showing a possible delay period between exposure to low doses of radiation and developing cancer. However, this study has been criticized by others for various weaknesses in methodology, and others believe that no increased incidence of cancer is indicated by an appropriate interpretation of the data. Scientific review and evaluation should be encouraged in order to continually refine, and modify if necessary, policies and procedures to protect public health.

[9] Studies by E.S. Gilbert and others, of radiation workers at DOE's Hanford, Oak Ridge, and Rocky Flats facilities failed to reveal any increased incidence of cancer among workers. This analysis included an evaluation of the Wing study and failed to confirm the findings of that study when examined alone or when combined with the data from the other two facilities.

[10] These studies are discussed in the fifth report, issued in 1990, by the "Committee on the Biological Effects of Ionizing Radiations" (BEIR) of the National Academy of Sciences (known as the "BEIR V" report), and by Upton, Shore, and Harley, among others.

Figure 3-F
Relative Toxicity of A Typical Metric Ton of Hazardous Versus Radioactive Waste



This figure was compiled from the following sources:

Battelle-Columbus Laboratories, "Assessment of Industrial Hazardous Waste Practices; Electroplating and Metal Finishing Industries," 1976, US EPA.

Calspan Corporation, "Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry," 1979, US EPA.

Cohen, J.J. and Tonnessen, R.A., "Survey of Naturally Occurring Hazardous Materials in Deep Geological Formation: A Perspective on the Relative Hazard in Deep Burial of Nuclear Waste," 1977, Lawrence Livermore Laboratory, UCRL-52199.

Gruber, G.I, "Assessment of Industrial Waste Practices, Organic Chemicals, Pesticides and Explosives Industries," 1975, US EPA SW-118c.

Jacobs Engineering Co., "Assessment of Industrial Hazardous Waste Practices, Petroleum Refining Industry," 1976, US EPA.

US Nuclear Regulatory Commission, "Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," 1976, NUREG-0116.

US Nuclear Regulatory Commission, "A Classification System for Radioactive Waste Disposal - What Waste Goes Where?" 1978, NUREG-0456.

Versar, Inc., "Assessment of Industrial Hazardous Waste Practices, Inorganic Chemicals Industry," 1975, US EPA SW-104c.

Source: Domsife, W.P., "A Perspective on the Relative Hazard of Low-Level Radioactive Waste Disposal," Proceedings of the Health Physics Society Twelfth Midyear Topical Symposium, Low-Level Radioactive Waste Management. EPA 520/3-79-002. 1979.

Although health impacts of low doses of radiation are not clearly established, some efforts have been made, based on the preponderance of data, to compare radiation health effects with those of hazardous materials. One technical study develops a "radiotoxic hazard index" to compare the relative potential hazard of radioactive waste versus hazardous waste. The radiotoxic hazard index is defined as a measure of the amount of water required to dilute a certain quantity of radioactive isotopes to the concentrations permissible under U.S. Environmental Protection Agency (EPA) drinking water regulations. Those regulations set a maximum allowable whole body or internal organ dose of 4 millirem per year for most isotopes. The exceptions to this level are the bone-seeking radioactive elements, such as Radium-226, for which limits are based on a cancer risk of approximately 1×10^{-6} per person year, which is about the same as the whole body exposure risk of 4 millirem per year. Each index number is calculated by dividing the initial quantity in curies by the permissible concentration in curies per cubic meter.

Figure 3-F illustrates the relative toxicity of various materials based upon this particular index. The figure is included to be illustrative only, and to show the toxicity comparisons of a metric ton of various types of waste calculated on this basis. Each of the lines representing a waste stream were extrapolated from various reports, which are listed under the figure. The increase in the long-term toxicity of LLRW above a relatively stable level shown after 100,000 years was calculated based on the decay of Uranium-238 into other radioactive elements, such as radium, radon, and lead. The toxic heavy metal waste accounts for the non-decaying portion of the hazardous waste line.

Although this kind of comparison attempts to place LLRW in perspective relative to other hazards, both types of waste can be toxic to living things; both must be managed, stored, treated, and disposed of in an environmentally suitable manner that protects the public's health and safety.

The debate on the health effects of low-dose radiation will continue, and differing scientific and non-scientific viewpoints will be expressed. In the meantime, however, Massachusetts must follow standards set by national and international radiation agencies in protecting the public from radiation exposure. These standards are considered by most scientists to ensure public health protection by keeping radiation doses as low as reasonably achievable.

Chapters 11-13 discuss the requirements for treatment, storage, and disposal facilities to ensure the public's health and safety. The next section of this chapter summarizes the standards developed by federal agencies to protect patients, occupational workers, and the public.

3.6 Radiation Protection Standards

Radiation protection standards have been developed and implemented by federal and state agencies to limit the possibility of radiation-induced effects in individuals exposed to radiation, and in their offspring. As with many environmental and health issues, differences of opinion exist whether the standards should incorporate elements of "reasonableness," "acceptability," and "economics" relative to the benefits from activities that cause exposure.

Ever since radiation dose limits were established, (starting in 1934 with occupational exposure standards set by the National Council on Radiation Protection), new data and greater safety measures have resulted in a strengthening of these limits. Allowable human exposure levels continue to be revised downward, resulting in lower allowable doses of radiation exposure to the public and to workers.

NRC and EPA Standards

Standards for protection against radiation exposure have been established by the NRC, which has

authority over all licensed activities of most radioactive materials users. In states that have "agreements" with the NRC allowing the states to regulate radioactive materials and waste, the radiation protection standards of the NRC are followed by state regulatory agencies.[11]

The NRC standards apply to both radioactive materials (before any waste is generated) and LLRW. Separate standards apply to the general public and to occupational workers.

As stated earlier in this chapter, the NRC does not regulate NORM or NARM wastes. However, NRC standards (10 CFR Part 20.1001) explicitly state NRC's interest in ensuring that the total dose of licensed and unlicensed (NARM) radiation sources does not exceed the standards they have established.

In 1986, the NRC proposed an upgrade of its radiation protection standards. The new limits, summarized below, were originally announced in December, 1990, and were published in final form in the Federal Register in May, 1991. The revised Part 20 became effective on Jan. 1, 1994.

Revised Occupational Radiation Dose Limits

The NRC maximum occupational dose is as follows:

(1) an annual limit, which is the more limiting of:

  (a) the total effective dose equivalent being equal to 5 rems; or

  (b) the sum of the deep dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rems.

(2) the annual limits to the lens of the eye, to the skin, and to the extremities, which are:

  (a) an eye dose equivalent to 15 rems and;

  (b) a shallow-dose equivalent of 50 rems to the skin or any extremity. [10 CFR 20.1201]

The occupational dose limits for minors are 10% of the adult limits, and doses to the fetus/embryo of a declared pregnant woman due to occupational exposure is limited to 0.5 rem. Other requirements and limits are also specified for controlling occupational exposure.

Radiation Dose Limits for the Public

The NRC regulation, 10 CFR 20.1301, also restricts exposure to members of the public from licensed facilities as follows:

(1) the total effective dose equivalent to individual members of the public from the licensed operation does not exceed 0.1 rem (100 millirem) in a year.

(2) the dose in any unrestricted area from external sources does not exceed 0.002 rem (2 millirem) in any one hour.

NRC may allow up to 0.5 rem (500 millirem) in a year to an individual member of the public under

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[11] See Chapter 2 for a detailed discussion of the Agreement State program.

some circumstances, such as nuclear medicine treatment for cancer, and by specific petition of a licensee.

The regulation also specifies maximum derived air concentrations (DAC's) for occupational exposure; annual limit on intake (ALI) values for radioactive materials in air and water effluents; and concentrations for release to sewer systems. These limits are listed in Appendix B of 10 CFR Part 20.

Other Limits

Additional limits on radioactivity are set by NRC in its regulations pertaining to LLRW disposal facilities, and by EPA in its drinking water standards. The NRC requirement, found in 10 CFR 61.41, regulations for LLRW disposal facilities, provides that:

> "Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable."

The National Primary Drinking Water Standards promulgated by EPA in 1976 set maximum allowable levels of radionuclides in public water supplies. These requirements, found in 40 CFR Part 141, are summarized as follows:

Radioactivity	Limit
Combined Radium-226 and Radium-228	5 Picocuries/Liter
Gross alpha activity (including Radium-226, but excluding radon and uranium)	15 Picocuries/Liter
Beta and gamma-ray activity for man-made radionuclides (total body or organ dose based on 2 liters per day of drinking water	4 Millirem/year
Uranium and thorium	10 Picocuries/Liter

Similarly, EPA regulations in 40 CFR Part 190 limit total doses to members of the public from all sources in the uranium fuel cycle to 25 millirem per year. This limit includes exposure from uranium fuel cycle facilities such as uranium mining and milling, uranium conversion, uranium enrichment, fuel fabrication, nuclear power reactors, spent fuel storage, spent fuel reprocessing, and disposal.

In 1990, the EPA proposed a reduction in this standard for nuclear power plant emissions to 10 millirem per year. As a result, the Massachusetts Department of Public Health reviewed the EPA's studies, and concluded that the lower dose level was preferable to the 25 million standard from a public health standpoint. Since the DPH decision, the EPA announced its intention to withdraw its proposed new standard. At the end of 1993, DPH had not moved to adopt its proposed 10 millirem rule.

The final NRC standards (10 CFR Part 20) accounted for most of the recommendations contained in the 1987 National Council on Radiation Protection and Measurements (NCRP) report that were consistent with earlier recommendations of the International Commission on Radiological Protection (ICRP). Some NRC standards were not consistent with these international and national recommendations, because there had not been an opportunity for public comment on them when the proposed revision was issued in 1986.

In addition, several other studies and recommendations have been released since 1986, when the NRC first published its intention to amend "Part 20," including the following:

(1) The 1988 Report of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR-88)

(2) The 1988 Report of the National Academy of Sciences' Committee on the Biological Effects of Ionizing Radiation (BEIR-IV)

(3) The 1990 Report of the National Academy of Sciences' Committee on the Biological Effects of Ionizing Radiation (BEIR-V)

(4) ICRP 1990 Recommendations (Press Release)

All of these reports were issued subsequent to the publication of the proposed revision to 10 CFR Part 20 in 1986. However, the 1990 ICRP recommendations were based, in part, on the newer studies of radiation risks contained in reports (1) - (3) above.

For example, the BEIR-V report, cited above, concluded that the risk of getting cancer from low levels of radiation appears to be four times higher than the committee previously estimated in its BEIR III report. While the BEIR committee study notes that its new estimate of cancer risk should cause no concern for the average person -- since the public is not exposed to enough radiation to exceed even present standards, the committee's conclusions, along with those of the ICRP, may result in a tightening of regulatory standards in the future.

"ALARA" Concept

NRC regulations also express the agency's view that all users of radioactive materials "shall use, to the extent practicable, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA)." [10 CFR 20.1101(b)] The regulations describe the ALARA objective to be consistent with the purposes for which the licensed activity is undertaken, taking into account the state of technology, and the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to the utilization of atomic energy and licensed materials in the public interest. [10 CFR 20.1(c)]

Radiation Standards Summary

Current NRC regulations reflect most of the latest recommendations of national and international expert groups that study radiation risks. NRC and EPA regulations limit doses to members of the public from licensed facilities in general to 100 millirem per year. However, doses to individual members of the public from all sources and facilities in the nuclear fuel cycle are limited to 25 millirem per year. Doses to members of the public from LLRW disposal facilities are also limited to 25 millirem per year, with some allowable doses to specific organs permitted up to 75 millirem per year.[12] Occupational dose limits are generally set at 5 rem per year for adult workers.

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[12] The NRC allowable doses from an LLRW disposal facility are "organ" doses, not "effective dose equivalent" doses. For example, a 75 millirem dose to the thyroid is an effective dose equivalent of only 4.5 millirem.

It should also be remembered that these limits are "boundaries" rather than "design criteria." The application of the ALARA principle invoked by the NRC is Intended to keep exposures to both radiation workers and the general public at levels lower than these standards.

Although the health impacts of ionizing radiation are known at high dose rates and high doses, the effects at low doses are not as well established. The Management Board reviewed information available on the health effects of very low-dose radiation (1-25 millirem per year). To obtain additional input, the Board sponsored a seminar on very low-dose radiation health effects. Although there are some uncertainties associated with the actual magnitude of health effects at low doses, the Board has arrived at the conclusion that the apparent risks to workers and the public at the levels of exposure currently allowed by regulation are sufficiently low to allow the Board to proceed with its LLRW management programs.

As a result, the current regulatory scheme for LLRW management, facility development, and radiation protection of the public is believed to be adequate, based on current knowledge, and acknowledgement of scientific uncertainty regarding the health effects of ionizing radiation at very low dose and dose rates (1-25 millirem per year), such that development of LLRW facilities can proceed, if the Board votes to develop such facilities in the Commonwealth. The requirements of Chapter 111H and Massachusetts General Laws c.111 (Massachusetts radiation protection requirements) and the regulations of the Management Board, DPH, and DEP, supplement the federal regulations to ensure additional public health protection. The Board will actively monitor radiation health studies, and related science and technology, and revise development plans and standards as required to reflect the latest information.

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Chapter 4: Characterizing LLRW Generated in Massachusetts

4.1 Introduction

For several decades, Massachusetts citizens have shown a keen interest in issues relating to radiation and radioactivity. Many of the residents of communities abutting the two nuclear-powered electric generating plants in Plymouth and Rowe have been especially concerned about the operating and decommissioning activities of those facilities; persons residing near other locations where radioactive materials are used are eager to understand the relationship of those uses to their daily lives.

Most citizens are not familiar with the numerous applications of radioactive materials in Massachusetts; many confuse "hazardous" waste, and "radioactive" waste.[1] Sometimes there is also misunderstanding about what wastes are categorized as "low-level radioactive waste" (LLRW), and what wastes are categorized as "high-level radioactive waste" (HLRW).

LLRW is defined in both federal and state law by a series of exclusions. The State's Low-Level Radioactive Waste Management Act, Massachusetts General Laws c.111H (Chapter 111H), defines LLRW as "radioactive material that:

(1) is neither high-level waste, nor spent nuclear fuel, nor byproduct material as defined in Section 11(e)(2) of the Atomic Energy Act of 1954, as amended, 42 U.S.C. Section 2014(e); and

(2) is classified by the federal government as low-level radioactive waste, but not including waste which remains a federal responsibility, as designated in Section 3(b) of the Low-Level Radioactive Waste Policy Act, as amended, 42 U.S.C. Section 2021c(b), in effect as of the effective date of the passage of Chapter 111H." (December 8, 1987).

This definition emerged from the federal definition of LLRW which is found in the Low-Level Radioactive

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[1] Both "hazardous" wastes and "radioactive" wastes can be "hazardous." The terms are defined by federal and state laws, and years of study and regulatory controls, and therefore have distinct meanings. "Hazardous waste" is toxic, chemical waste, which, because of its quantity, concentration, or physical, chemical, or infectious characteristics, may cause or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible illness, or may pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of or otherwise managed. "Radioactive waste" is waste that is contaminated by radioactive materials. Because doses of radiation can change the chemical structure of living tissue or other matter, radioactive wastes, like toxic chemical "hazardous" wastes, are a concern to public health and the environment if improperly used, treated, stored, transported, or disposed of.

Waste Policy Act of 1980, P.L. 96-573. That law defines LLRW as:

"...radioactive waste not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or byproduct material as defined in Section 11e(2) of the Atomic Energy Act of 1954."

Both the state and federal definitions of LLRW define it to include some byproduct material and to exclude other byproduct material. "Byproduct material" is defined by the U.S. Nuclear Regulatory Commission (NRC) as "any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material." "Special nuclear material" refers to plutonium, uranium enriched in the isotopes 233 or 235, or any material artificially enriched in any of these substances. The "byproduct" material which is excluded from the LLRW definition is waste from byproduct material used in the production of nuclear weapons. NRC regulations limit the quantities of byproduct material that can be used, manufactured, produced, transferred, received, or possessed.

Since LLRW is defined by these exclusions, it is helpful to define each of the other types of radioactive waste that are not LLRW. Other kinds of radioactive waste include high-level radioactive waste (HLW), spent nuclear fuel, transuranic waste, uranium mill tailings, NARM (Naturally-occurring or Accelerator-produced Radioactive Materials) waste, NORM (Naturally-Occurring Radioactive Materials) waste, and Greater than Class C waste. Definitions of these "other" radioactive wastes appear in Table 4-1.

In contrast to LLRW, HLRW and spent nuclear fuel contains much higher concentrations of both short and long lived-radionuclides.

With the exception of NORM, and NARM waste, radioactive waste types other than LLRW are the responsibility of the federal government. NARM/NORM users and NARM/NORM waste producers in Massachusetts are regulated by the Department of Public Health (DPH) under Massachusetts General Laws c.111 and by the Department of Labor and Industries (DLI) under Massachusetts General Laws c.149.

This chapter discusses the forms in which LLRW can be found, and the types of companies and institutions that generate LLRW in the course of their use of radioactive materials. Data summarizing recent waste volumes and radioactivity is also provided.

Each year the Low-Level Radioactive Waste Management Board issues a report based on its annual survey of radioactive materials users. More complete information about a given year of LLRW production and disposition is contained in the survey reports. The survey acts as a data acquisition tool that is an integral part of the "total hazard" waste classification system required by Chapter 111H. That system is described in detail in Chapter 7 of this volume. It must categorize all LLRW generated, treated, or disposed of in the Commonwealth primarily on the basis of:

- the radiological toxicity and radioactive half-life[2] of the radioactive material in the waste;
- the principal radionuclides present in the waste, and their concentrations, specific radioactivity, chemical and biological toxicity and form, chemical reactivity, and volume; and
- other characteristics that the Management Board determines are necessary to properly manage

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[2] The "half-life" is the time in which half of the atoms of a particular radioactive substance disintegrate to another nuclear form. Each radionuclide has a unique half-life, varying from millionths of a second to billions of years.

Table 4-1
The "Other" Radioactive Wastes

High-level radioactive waste (HLRW) is defined in the federal Nuclear Waste Policy Act of 1982, as:

"(a) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and (b) other highly radioactive material that the Nuclear Regulatory Commission, consistent with existing law, determines by rule requires permanent isolation."

The U.S. Nuclear Regulatory Commission (NRC) also defines HLRW [10 CFR 60]:

"High-level radioactive waste (HLRW) means: (1) irradiated reactor fuel; (2) liquid wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel; and (3) solids into which such liquid wastes have been converted."

Spent fuel, another type of radioactive waste, is defined in the Nuclear Waste Policy Act as:

"fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing."

Transuranic (TRU) wastes are defined by the U.S. Environmental Protection Agency (EPA) in 40 CFR 191:

"wastes containing more than 100 nanocuries per gram of alpha-emitting transuranic isotopes, with half-lives greater than 20 years." Transuranic isotopes are man-made and have atomic numbers greater than 92. They are less intensely radioactive than HLRW.

Waste produced from uranium mill tailings are the scraps or residues which remain from the chemical processing, or "milling," of ore to remove the uranium. The uranium generally is mined for use in the nuclear power industry and various defense related activities. Uranium mill tailings are not generated in Massachusetts, since no uranium mining activities exist in the state.

NARM waste comes from Naturally-occurring or Accelerator-produced Radioactive Materials. NARM waste can be classified in two ways. The first is discrete NARM material produced in a cyclotron or other type of accelerator which is small in volume and high in radioactivity. Examples of this type of NARM waste include radium needles used in medicine, and water filters from processing radium-contaminated ground waters. The second type of NARM waste is diffuse material which is generally lower radioactivity radium-contaminated soil at locations where radium was used in manufacturing or where natural deposits of radium exist, or materials containing concentrations of radium or other naturally-occurring radioactive isotopes.[1]

Naturally Occurring Radioactive Material (NORM) is radioactive material that has a natural source. It is a subcategory of NARM waste.

Greater than Class C wastes (GTCC) are also called "orphan" wastes because they do not fall into either the LLRW category or the HLRW category. They are defined by their concentration of radioactive isotopes, and have a higher percentage than LLRW, but a lower percentage than HLRW. These wastes are defined by NRC in 10 CFR 61.55 as "waste that is not generally acceptable for near-surface disposal and whose radionuclide concentrations exceed those in Table 1 and Table 2 of 10 CFR 61.55."

Responsibility for GTCC waste disposal belongs to the federal government.

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1 Federal law does not assign responsibility over NARM waste to either the states or the federal government. Because the federal Resource, Conservation and Recovery Act (RCRA, Public Law 94-580) which regulates hazardous waste does not explicitly exclude NARM from EPA authority, as the law does with other types of radioactive material (except mixed waste which is both hazardous and radioactive), the EPA could regulate NARM waste. So far, it has not chosen to do so. However, 28 states, including Massachusetts, have passed laws regulating NARM.

all types of LLRW. [Chapter 111H, section 12(b)(1)]

A survey is conducted annually by the Management Board to collect data on all of the licensed and registered users of radioactive materials in the Commonwealth. The survey is required pursuant to section 7 of Chapter 111H, which mandates the collection of information concerning the type, volume, radioactivity, sources, and characteristics of the LLRW generated, treated, stored, transported, or disposed of, as well as the radioactive materials users' current and projected LLRW management activities. These activities include minimizing the radioactive material "sources" that result in LLRW; reducing the volume of LLRW generated; storing LLRW on site to allow waste containing short half-life material to decay to very low radiation levels so that it can be disposed of as non-radioactive trash; and treatment, packaging, and transportation practices.

Survey results assist the Management Board in establishing policy on LLRW storage, treatment, and disposal. For example, information from the 1990 survey led the Board to conclude in January, 1991, that no need existed to site, construct, and operate an interim centralized storage facility[3] in the Commonwealth for waste produced by "small" volume generators after the Barnwell, South Carolina, disposal site is no longer available to LLRW generators from Massachusetts and other states. The 1990 survey results revealed that all "large" volume generators had the capacity to store their waste on site until a disposal solution was found. The results also showed that no small volume generators would have "serious" space problems in conducting on-site storage.

Survey data from the 1992 questionnaire continued to support the Management Board policy regarding the ability of both large and small volume LLRW generators to provide on-site storage on an interim basis after access is lost to the disposal sites.[4] Survey data also enabled the Board to make the "determinations of need" regarding siting, development, operation and closure of storage, treatment, or disposal facilities within the State, as required by Chapter 111H. Those determinations are discussed in depth in Chapter 15.

4.2 History of Massachusetts Radioactive Materials User Surveys

A survey of radioactive materials users in the Commonwealth has been conducted annually by the Management Board to collect 1989 and subsequent years' data. Prior to the establishment by the Management Board of a yearly survey questionnaire, two earlier surveys were completed:

(1) Low-Level Radioactive Waste Management Survey, prepared by EG&G Idaho, Inc. for the U.S. Department of Energy (DOE) and DPH, October, 1982;

(2) The Analysis of Low-Level Radioactive Wastes Generated in Massachusetts, prepared by Stone

[3] The NRC, which licenses and regulates the use of radioactive materials in the Commonwealth, does not allow LLRW storage as a substitute for disposal. "Interim" storage may be conducted for no longer than a five-year period, pursuant to NRC guidelines. A detailed discussion of interim storage policies can be found in Chapter 12.

[4] The 1985 federal Low-Level Radioactive Waste Policy Amendments Act authorized the three states that had, for years, provided disposal for LLRW produced in Massachusetts (and other states) the authority to cease accepting waste from outside their regions after 1992. One of those states -- Washington -- ceased taking Massachusetts waste. One of those states -- Nevada -- closed its disposal site. The third state -- South Carolina -- agreed to accept out-of-region LLRW for disposal through June 30, 1994.

& Webster Engineering Corporation and the Analytic Sciences Corporation for the Massachusetts Special Legislative Commission on Low-Level Radioactive Waste, April, 1985.

The Intent of the 1982 survey was to determine what data needed to be collected from LLRW generators and to develop a suitable questionnaire to elicit this information from them. The 1985 survey was part of a study conducted by the Massachusetts Special Legislative Commission. The Commission, appointed by Governor Edward King and the Legislature, was charged with conducting a statewide assessment to evaluate the LLRW management situation in the Commonwealth, and recommend solutions. The 1982 and 1985 surveys were one-time events that used unrelated methods to gather LLRW information.

The 1982 waste management questionnaire, developed by Inter/Face Associates Inc., Incorporated input from DPH's Radiation Control Program and EG&G Idaho (the contractor that administers DOE's LLRW management program). The form contained four sections and 22 questions, with each section pertaining to a different "class" of radioactive materials user as follows:

(1) licensees who no longer use radioactive material;

(2) licensees who use radioactive material but do not generate LLRW;

(3) licensees who generate LLRW but can eliminate the radioactivity through the treatment of waste by storage for decay, or other management methods, and therefore do not ship waste to a licensed LLRW disposal facility; and

(4) licensees who ship LLRW for disposal.

The 1982 questionnaire was sent to 390 NRC licensees in the Commonwealth, of whom 98.2% responded. The results revealed that 266,253 cubic feet of waste was shipped for disposal In 1981, with 52% produced by the commercial sector, 38% by utilities, 6% by medical generators, and 4% by the academic sector.

The 1985 survey involved personal interviews with 12 generators that produced the majority of LLRW in the Commonwealth. They were: Massachusetts Institute of Technology, Harvard University, Damon Biotech, Travenol-Genentech, Boston Edison, Yankee Atomic, Nuclear Metals, Du Pont NEN Products, M/A Com, Cambridge Medical Diagnostics, Boston University Medical Center, and the U.S. Army Materials Testing Laboratory.

The goal of each interview was to:

(1) obtain actual data on waste volumes shipped for disposal;

(2) obtain estimates of waste projections based on present and future volume reduction techniques, business plans, and technologies as applied to their areas of business; economics of generating wastes; and characteristics of waste shipped for disposal; and

(3) develop the basis for a planning document for the management of LLRW in the Commonwealth.

The results of that survey revealed that in 1984, 180,348 cubic feet of waste was shipped for disposal. The report did not provide an extensive breakdown of the survey data, but it did make volume and classification projections through the year 2020. The study estimated that 96% of all Massachusetts LLRW is Class A. The volume projected to require shipment for disposal in 1991 was 122,000 cubic feet. Considering this projection and the fact that the volume <u>actually</u> shipped for disposal in 1991 was 42,686

cubic feet, a significant improvement has been made by the generator community in limiting the amount of LLRW produced and packaged for disposal.

Annual Survey Initiated

Beginning in 1989, the Management Board has surveyed LLRW generators annually. Chapter 111H requires the yearly collection of LLRW data, and directs either the DPH or the Management Board to conduct this task. Information required by law to be gathered annually Includes:

- detailed and accurate information concerning the type, volume, radioactivity, source and characteristics of the LLRW generated, treated, stored, transported, or disposed of;
- current and projected LLRW management activities, including source minimization, volume minimization, on-site storage, treatment, packaging, and transportation practices; and
- any other information determined to be necessary by the Board or DPH.

Since the first Management Board survey, questions have been added or eliminated each year in an effort to streamline the survey instrument, and to sort out the fundamental areas where data needed to be collected. The current survey form is based on earlier surveys, but is presented in a spreadsheet format that facilitates electronic storage and data manipulation. Since 1992, the Management Board has made the form available on computer disk, for ease of completion and data compilation.

4.3 Massachusetts LLRW Types and Sources

Some of the licensed radioactive materials users in Massachusetts produce LLRW that must be managed by disposal at a licensed LLRW disposal facility. Many others generate waste that is managed by a variety of other methods, and others do not generate any waste.

Some radioactive materials users produce LLRW with radioactivity that decays[5] to minute quantities in relatively short periods of time (from minutes to a few years). This waste is stored on site so that this decay process (called "storage for decay") can occur, and the waste involved does not require disposal in an LLRW disposal facility.

Some licensees use radioactive materials encapsulated in a shell of non-radioactive material. These "sealed sources" enable the radiation that penetrates the shell to be used for various controlled purposes, but prevents radioactive material or contamination from being transmitted outside the sealed shell. Their use does not normally result in the generation of any LLRW, although a related LLRW waste stream may result from later disposal by the user or manufacturer of sealed sources which are no longer useful.

LLRW resulting from the uses of radioactive materials takes a variety of forms. LLRW includes:

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[5] Radioactive atoms "decay," transforming the nucleus of a radioactive atom into the nucleus of another species. The rate of nuclear transformations occurring per unit of time is called the "activity." Radioactivity is measured in "curies." A curie is that quantity of a radioactive material that produces 37 billion nuclear transformations or disintegrations per second. As radioactive atoms decay, they eventually yield a more stable and ultimately non-radioactive element.

- radioactively contaminated dry, solid wastes such as wood, clothing, paper, and metal;
- concentrates from evaporation processes;
- hardware which has been activated as a result of its proximity to certain nuclear radiation sources;
- filters and filter media used in purifying various process streams;
- ion exchange resins used in water purification and chemical extraction processes;
- contaminated aqueous and organic liquids used in various analytical procedures and decontamination processes;
- contaminated used oils from machinery and processes that use radioactive materials;
- contaminated soil and rubble from the decommissioning and remediation of various facilities;
- biological waste such as animal carcasses and tissues from biological and medical research and medical diagnosis and treatment; and
- sludge from various processes.

Also, a small portion of LLRW contains hazardous chemicals, or exhibits hazardous materials properties, and is referred to as "mixed" waste.

There are approximately 450 radioactive materials users in Massachusetts. The total number of companies licensed by the NRC or registered by the DLI varies from year to year due to the expiration or termination of some licenses and registrations, and the issuance of new ones.

The Management Board categorizes radioactive materials users by generator "types" for the purposes of monitoring their actions to fulfill federal mandates, and collecting data on waste volume, radioactivity, and other characteristics necessary to determine future disposal needs. These five waste producer types are (1) commercial, (2) academic, (3) health care, (4) utilities, and (5) government.

Commercial Waste Producers

Commercial activities in Massachusetts that produce LLRW include the production of radiopharmaceuticals, research and development, monitoring services, nondestructive testing, production monitoring, quality control testing, sealed source manufacture, biotechnology products and biomedical/organic products. Many of these activities are directly related to the educational/research and health care generators, for example, the manufacture of radiopharmaceuticals for hospitals and universities. In the area of research on new medicines, 80% of all new drugs are tested for safety and effectiveness using radioactive materials, according to the President of the American College of Nuclear Physicians.[6] Table 4-2 lists the principal radionuclides typically found in LLRW produced in Massachusetts by commercial generators.

The following kinds of waste are produced by commercial LLRW generators:

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[6] Statement made by Dr. Conrad Nagle, Chief of Nuclear Medicine at William Beaumont Hospital in Troy, Michigan, and President of the American College of Nuclear Physicians. Washington, DC, October 27, 1993.

Table 4-2
Principal Radionuclides in Massachusetts Commercial LLRW
(curies per year)

Radionuclide	Half-life	Typical Quantity
Hydrogen-3	12.3 years	44,463
Iridium-192	73.8 days	21,004
Sulphur-35	87.2 days	962
Cobalt-60	5.27 years	477
Carbon-14	5,730 years	331
Phosphorus-32	14.3 days	195
Americium-241	432 years	131
Krypton-85	10.7 years	67
Iodine-125	60.1 days	34
Gallium-67	3.26 days	27
Technetium-99M	6 hours	26
Cesium-137	30.2 years	15
Molybdenum-99	2.75 days	12
Radium-226	1,600 years	10
Chromium-51	27.7 days	10
Cobalt-57	271 days	9
Nickel-63	100 years	9
Iodine-131	8.04 days	8
Thallium-201	3.04 days	8
Uranium-238	4,468,000,000 years	6
Ytterbium-169	32.03 days	5
Thallium-202	12.2 days	4
Strontium-90	29.1 years	1
Iodine-123	0.55 days	1
Gadolinium-153	242 days	1
Iron-55	2.73 years	1

Source: Massachusetts Low-Level Radioactive Waste Management Board.

Radiopharmaceutical wastes: A radiopharmaceutical is a radioactive isotope that works in combination with a chemical compound designed to concentrate in a particular organ or area of the body. After the radiopharmaceutical is injected, ingested, or inhaled into the body. the chemical "tagged" with the radioactive isotope localizes in the area to be diagnosed, and gamma cameras or radiation-sensitive scan-

ners produce images of the areas of interest. Other diagnostic and therapeutic procedures also can be conducted with various radioactive compounds.

Prior to the development of nuclear medical procedures using radiopharmaceuticals, the only way to detect many types of cancer was through invasive surgery. Such operations could not detect the extent of the cancer's spread, or locate the cancer in its earliest stages, an important guide for proper treatment.

Radiopharmaceuticals are given in very small doses, between one and 50 microcuries.[7]

The most frequently-used radiopharmaceutical, Technetium-99m, has a half-life of six hours. It is synthesized from molybdenum-99, which has a half-life of 67 hours. Technetium-99m is an effective indicator, and is used in bone scans to identify disorders ranging from hairline fractures to cancer in the bone. Conventional bone x-rays do not detect a cancer until it has progressed to later stages, when nearly 50% of the calcium in the bone has been lost, but the technetium-99m nuclear medicine procedure can detect cancer in its earliest stages. Bone scans are the most commonly performed procedure in nuclear medicine.

One of the largest producers of radioactive chemicals and radiopharmaceuticals in the country is located in Boston and in Billerica. E.I. Du Pont De Nemours and Du Pont Merck Pharmaceuticals convert radioactive chemicals into forms useful in medicine and research. The radionuclides used in these applications are produced directly in nuclear reactors, particle accelerators, and isotope generators. The waste produced in radiopharmaceutical production contains mainly Carbon-14, Hydrogen-3 (tritium), Cesium-137, and Iodine-125, although over 100 radionuclides are incorporated into medically-related products by Du Pont. Several of the products produced decay quickly to stable compounds, but the manufacturing process also creates radioactive waste with longer half-lives.

Sealed source wastes: Radioactive isotopes are used in the manufacture of several everyday commercial products such as smoke detectors and self-illuminating exit signs, and in numerous types of measuring instruments. Within these products, the radioactive materials are encapsulated within a sealed stainless steel cylinder or capsule that can be replaced once the source has decayed to 30% or more of its original radioactivity. The owner may often keep the instrument while returning the sealed source to the manufacturer for a replacement.

Sealed sources are also used as sources of radiation (similar to X-ray equipment) that can "radiograph" or measure the integrity of building materials, bridge structural members, and welds in piping. Other types of radiography gauges are used to check wear and corrosion on metal, to survey geologic formations, to measure the density of items inside closed containers such as tanks or boxes, and to measure the moisture content of paint.

Academic Wastes

LLRW is produced in many of the universities in Massachusetts through activities including research in physics, biology, medicine, inorganic chemistry, materials analysis, and geology. Some of the waste is produced through the use of particle accelerators or small university nuclear research reactors. Some waste is also generated in the classroom, where radioactive materials are used for instructional purposes.

The three universities in Massachusetts that utilize small nuclear research reactors are Massachusetts Institute of Technology, the University of Massachusetts/Lowell, and Worcester Polytechnic Institute. Their wastes contribute only trace amounts of radioactivity to the Commonwealth's total waste stream.

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[7] A "microcurie" is one millionth of a curie.

Table 4-3 lists the principal radionuclides typically found in the LLRW produced in Massachusetts by academic generators, which are also the principal radionuclides typically found in the "health care" category of LLRW generators.

Table 4-3
Principal Radionuclides in Massachusetts Academic and Health Care LLRW
(curies per year)

Radionuclide	Half-life	Typcial Quantity
Technetium-99m	6 hours	2,428
Molybdenum-99	2.75 days	279
Thallium-201	3.04 days	53
Phosphorus-32	14.3 days	18
Gallium-67	3.26 days	14
Hydrogen-3	12.3 years	11
Iridium-192	73.8 days	11
Sulphur-35	87.2 days	9
Cobalt-60	5.27 years	5
Iodine-125	60.1 days	5
Iodine-123	0.55 days	4
Cesium-137	30.2 years	4
Iodine-131	8.04 days	3
Plutonium-239	17.97 years	2
Indium-111	2.8 days	2
Carbon-14	5,730 years	1
Chromium-51	27.7 days	1

Source: Massachusetts Low-Level Radioactive Waste Management Board.

Health Care Wastes

Nuclear medicine practices have become widely used in Massachusetts and the rest of the nation to diagnose and treat disease, including cancer. Diagnostic nuclear medicine includes activities such as measuring the uptake of radioactive drugs by different organs in a person's body, and "imaging" -- distributing radioactive drugs through the body or to individualized organs to detect tumors or other abnormalities. Therapeutic activities include using radioactive drugs internally and externally, as well as implanting radioactive devices on the body's surface.

For example, radionuclides are used to test inadequate thyroid production in newborn babies in time for treatment to avoid retardation. Tests such as the alpha feto protein test use radioactive materials to determine the condition of the fetus and placenta during high-risk pregnancies. In the treatment of heart

disease, blood cells "labeled" with Technetium-99m, which are pumped through the heart, can reveal or "image" the effects of heart disease on the inside of the heart. This procedure allows physicians to measure heart damage without using the alternative, but risky, cardiac catherization procedure.

Xenon-133 and Technetium-99m are used to identify and treat lung disease. Technetium-99m can also "label" phosphate compounds for earlier detection of bone cancer, fractures, or infection than can be accomplished with traditional x-rays. Thyroid cancer can be detected and treated using iodine-131.

Radiation therapy is used both outside and inside the body. Radiation therapy utilizes high doses of radiation, such as Iodine-131 and Cobalt-60, to treat thyroid, breast, bone, lymph, and other cancers. Internal radiation therapy involves the swallowing or injection of a radioactive substance which moves to the organ undergoing treatment. In addition, radionuclides sealed in capsules, needles, or wires can be implanted in the body for short periods of time to shrink or kill cancer tumors.

Tritium also is a common radionuclide found in medical wastes. It's half-life of 12.3 years is "long" for the medical radioactive isotopes. Iodine-125 is also frequently used, but its half-life is 60.14 days. Most of the radionuclides used in health care activities have less than seven-day half-lives.

An estimated 80 to 100 million nuclear medicine procedures are performed yearly in the United States.[8] In Massachusetts, hospital accreditation depends upon access to a nuclear medicine program.

The typical kinds of radioactive wastes generated by both academic/research activities and health care activities include:

Dry solids: These include protective clothing such as lab coats, shoe covers, plastic eye protectors, rags, paper, and packaging materials.

Liquid scintillation waste: Vials of scintillation liquids or "cocktails" are used extensively in medical research, as well as in commercial research. The scintillation liquids consist of organic fluids (usually toluene, xylene or benzene) packaged in plastic or glass vials. After the body tissue, cell, or other material is tagged with a radionuclide, it is mixed with the scintillation fluid. The energy created from the decay of the radionuclide causes the scintillation liquid to emit flashes of light, that can be counted by sophisticated machinery and provide the researcher with a precise measurement of the amount and type of radioactivity present. The researcher is therefore provided information to make decisions about the body tissue, cells, or other material under study.

Scintillation vials usually contain extremely small quantities of radioactive material. Researchers traditionally divide one millicurie[9] of tritium into 10 or more cell studies, using only a part of any one cell study in a given scintillation vial. This action dilutes the radioactive hazard of the vials, but means more vials are produced requiring treatment and disposal. Further discussion of treatment and disposal issues is contained in Chapters 8 (mixed waste) and 10 (waste minimization).

Organic liquids: Organic solvents other than scintillation fluids are produced through bioresearch. These include alcohol, aldehydes, ketones, and acids.

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[8] "Radiation Phobia: It Could be Hazardous to Your Health." Nuclear Industry, Third Quarter. U.S. Council for Energy Awareness, Washington, DC, 1991.

[9] A "millicurie" equals one-thousandth of a curie.

Aqueous liquids: Most of the liquid waste from the use of radionuclides in research and health care activities are in a water solution and are produced from washing contaminated laboratory containers and tools.

Biological waste: Because animals are used in biological research, their carcasses become LLRW if the animals were given radioactive drugs. Human and animal bedding and excreta, and the culture media using radionuclides, are also included in this category.

Gaseous waste: Gaseous Xenon-127 and Xenon-133 are used by hospitals to do ventilation tests of lung capacity. The gases can be trapped in charcoal filters to be disposed of as LLRW.

Table 4-3 lists the principal radionuclides typically found in LLRW produced in Massachusetts by health care activities.

Utility Wastes

As a by-product of generating electricity, nuclear-powered reactors produce LLRW and HLW. The kinds of waste produced by the two nuclear power facilities in Massachusetts (Boston Edison in Plymouth and Yankee Electric in Rowe) are:

Dry active waste: Dry trash including protective clothing, gloves, paper, plastics, air filters, and glass becomes contaminated during the normal operation of a power plant. Much of this waste is compacted to reduce its volume, either by using on-site compaction equipment or by sending the waste off site to a processor. It can also be incinerated, and some of this waste is sent to Tennessee for such treatment. No incineration of nuclear power plant wastes occurs in Massachusetts.

Equipment: Used equipment and tools that have become contaminated are non-compactible LLRW. They include activated or contaminated plant components such as piping, valves, control rods, and other worn-out parts.

Sludges (wet solids): Sludges are produced in the process of filtering contaminants from reactor water. They can be in the form of powdered resins, suspended solids, metal oxides, diatomaceous earth, and the evaporator concentrates, or "bottoms," produced during the evaporation of liquid wastes. These bottoms contain mixtures of borate or sulfate/salts, oils, and metal oxides, and comprise a large portion of reactor waste.

Liquid wastes: Power plants produce large quantities of wastewater, which is treated on site by filtration, evaporation or ion-exchange purification to concentrate the contaminants. Lubricating oils and greases are also included in this kind of waste. Liquids or their concentrates are required by federal regulations to be solidified before disposal.

Gases: Radioactive gases are also produced at nuclear power plants. They are filtered and held for decay before they are allowed to be discharged to the atmosphere.

Table 4-4 lists the principal radionuclides typically found in LLRW produced in Massachusetts by the two nuclear-powered utility companies.

Government Wastes

State and federal government activities also contribute to the production of LLRW. The DOE and the U.S. Department of Defense (DOD) are the largest producers among federal agencies. A variety of types

Table 4-4
Principal Radionuclides in Massachusetts Utility LLRW
(curies per year)

Radionuclide	Half-life	Typical Quantity
Iron-55	2.73 years	8,481
Cobalt-60	5.27 years	7,162
Cadmium-109	1.27 years	2,550
Nickel-63	100 years	811
Antimony-125	2.76 years	655
Manganese-54	312 days	655
Cesium-137	30.2 years	35
Cobalt-58	70.8 days	25
Chromium-51	27.7 days	20
Cesium-134	2.06 years	9
Iron-59	44.5 days	8
Barium-140	12.8 days	5
Cerium-144	285 days	4
Zinc-65	244 days	4
Hydrogen-3	12.3 years	3
Lanthanum-140	1.68 days	2
Strontium-89	50.5 days	1

Source: Massachusetts Low-Level Radioactive Waste Management Board.

of waste are generated as a result of DOE research in nuclear energy, reactor safety, and new technologies for treating waste. Wastes similar to those produced by commercial nuclear power plants are generated in the production and use of nuclear fuel for ships and submarines. Federal government LLRW involving nuclear weapons are not included in the State's "government" waste category. However, LLRW from federal hospital and research wastes, such as those produced at Veterans Hospitals and federal-government-run research clinics, are included in this category.

During the early 1990s, one of the largest government LLRW generators in Massachusetts was the U.S. Army, which was decommissioning its old nuclear reactor and radioactive materials research site at the Watertown Arsenal.[10] Other licensees in the "government" category include municipal hospitals, municipal water departments, and state agencies like the Massachusetts Department of Environmental Protection's Lawrence Experiment Station. Most of these licensees produce little or no LLRW.

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[10] More information about the U.S. Army decommissioning project, and other decommissioning activities, can be found in Chapter 14.

Table 4-5 lists the principal radionuclides typically found in LLRW produced in Massachusetts by government activities.

Table 4-5 Principal Radionuclides in Government LLRW Produced in Massachusetts (curies per year)		
Radionuclide	**Half-life**	**Typical Quantity**
Uranium-238	4,468,000,000 years	74.0
Cesium-137	30.2 years	0.611
Cobalt-60	5.3 years	0.611
Radium-226	1,600 years	0.611
Nickel-63	100 years	0.212
Hydrogen-3	12.3 years	0.2
Source: Massachusetts Low-Level Radioactive Waste Management Board.		

4.4 LLRW Volumes and Activity: National and State

By the end of 1992, approximately two-thirds of the annual and cumulative volumes of LLRW produced over the years and disposed of by land disposal or other means (i.e., ocean disposal) resulted from various DOE and DOD-related activities. The remaining one-third of the LLRW produced in the country resulted from commercial or other private sector uses of radioactive materials. Table 4-6 lists the volumes and radioactivity of the waste accumulated at DOE sites as compared with the amount of commercial LLRW disposed of at commercial LLRW disposal sites.

Table 4-6 Federal and Commercial LLRW Disposal Through 1992 (cubic feet and curies)				
Source of LLRW Generation	**Volume (cubic feet)**	**% Volume**	**Activity (curies)**	**% Activity**
U.S. Department of Energy	1,423,875	45.0%	477,668	30.2%
Commercial LLRW Generators	1,743,279	55.0%	1,102,000	69.8%
Source: U.S. Department of Energy, Low-Level Radioactive Waste Management Program. Idaho Falls, ID, 1993.				

U.S. data for total LLRW disposal at the three commercial disposal sites that remained open to the nation's LLRW generators through 1992 is shown in Table 4-7 and Figure 4-A. This table and figure show that 52% of the total LLRW produced in the country by non-federal-government (i.e., non-nuclear weapons-related) licensees originated from the commercial category of radioactive materials users, as compared to 60% of the LLRW produced in Massachusetts in 1992 (Table 4-8). Only 10% of the total activity shipped for disposal nationally resulted from the commercial category of waste producer, as compared to 57% of the activity produced in Massachusetts in 1992.

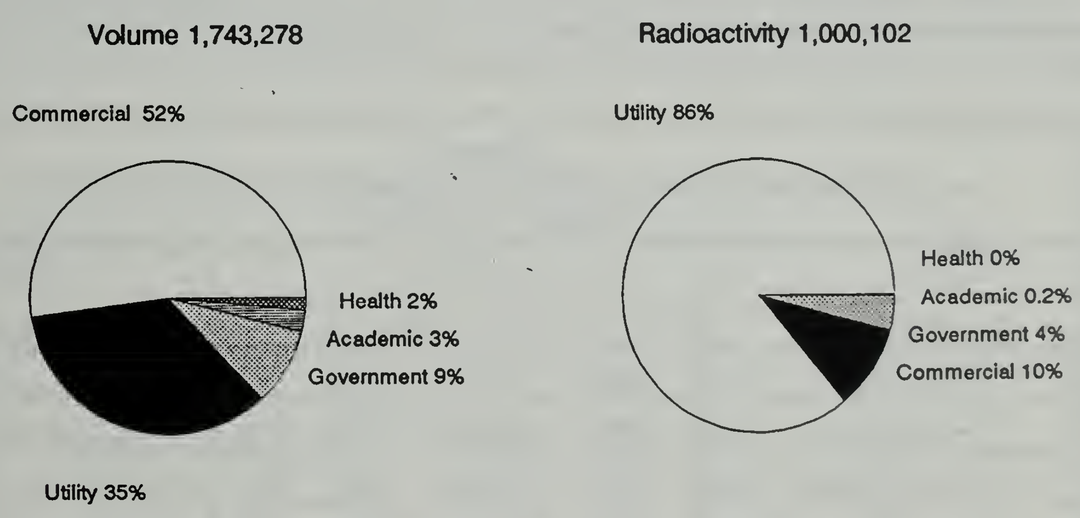
Table 4-7
1992 National Total of LLRW Received at Three Disposal Sites[1]
(cubic feet and curies)

Generator Category	Volume	Radioactivity
Academic	44,322	1,724
Commercial	908,452	100,090
Government (non-nuclear weapons-related)	158,186	40,780
Health	26,251	398
Utility	606,067	857,110
Total	1,743,278	1,000,102

[1] Data on various generator categories of disposal is not available from the fourth disposal site, run by Envirocare in Clive, Utah, which accepts limited types and concentrations of radionuclides. That site accepted a total of approximately 27 million cubic feet of LLRW through 1993.

Source: U.S. Department of Energy, National Low-Level Waste program. 1992 State-by-State Assessment of Low-Level Radioactive Wastes Received at Commercial Disposal Sites, DOE\LLW-181, Idaho Falls, ID, September, 1993.

Figure 4-A
1992 National Total LLRW Received at Three Commercial Disposal Sites[1] by Generator Category by Volume and Radioactivity
(cubic feet and curies)



[1] LLRW disposed of at Barnwell, South Carolina; Beatty, Nevada; and Hanford, Washington sites.

Source: U.S. Department of Energy, National Low-Level Waste Program. 1992 State-by-State Assessment of Low-Level Radioactive Wastes Received at Commercial Disposal Sites, DOE/LLW-181, Idaho Falls, ID, September, 1993.

In addition, nationally, 35% of the volume and 86% of the radioactivity came from utility waste in 1992. These data compare with 11% of the volume, and 43% of the radioactivity originating from Massachusetts utilities in 1992.

Before 1970, transuranic waste was accepted at the same commercial disposal sites used for LLRW disposal. The federal government (Atomic Energy Commission - AEC) changed its policy in 1970 and decided that TRU wastes should have greater confinement from the environment than to be buried in pits or trenches and covered with soil. Therefore, since 1970, TRU wastes have been stored for easy retrieval. Most of this waste (98%) can be handled with shielding by the waste container, and is classified as "contact-handled" TRU waste. The rest requires remote handling because of the emission of beta, gamma, and neutron emitters causing radiation levels greater than 200 millirem/hour. The figures shown in Table 4-6, therefore, include the TRU waste buried at the commercial sites prior to 1970.

4.5 Summary of Management Board Survey Information, 1989 to 1992

Data from the annual surveys for 1989, 1990, 1991, and 1992 reveal some interesting information about LLRW in Massachusetts, and, as noted, have been used by the Management Board to evaluate LLRW management policies and procedures.

Tables and figures in this section present four years of actual data plus three years of projections supplied by the generators in the most recent survey. Values have been rounded using standard methods, and may not equal 100%. Much of the information is grouped by generator category.

Volume Shipped for Disposal

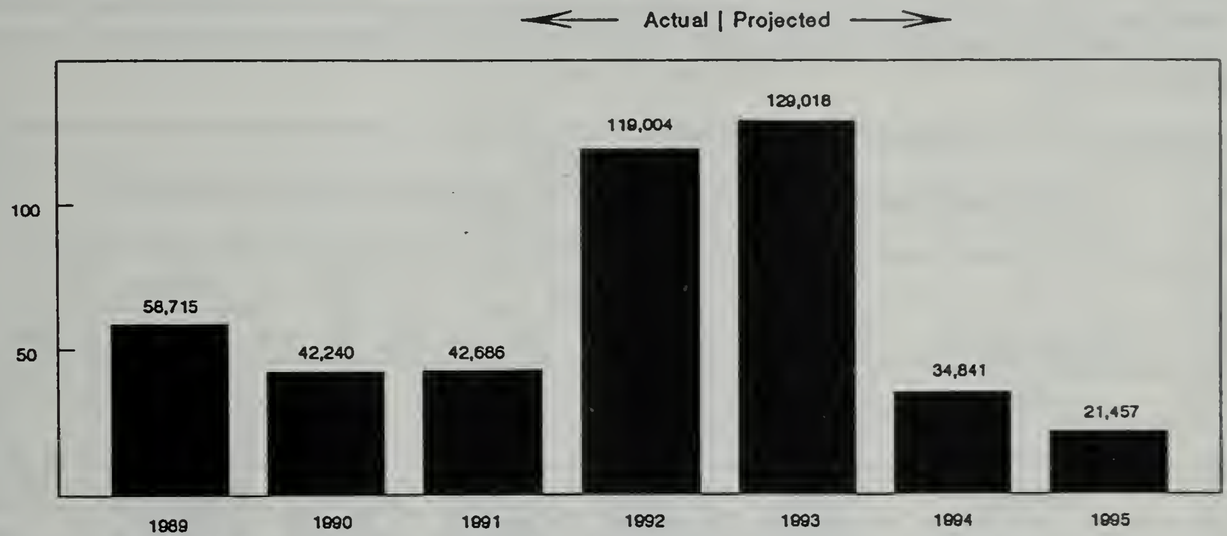
Table 4-8 and Figure 4-B show the total LLRW volume that was shipped for disposal in 1989-1992, and projections of 1993-1995 volume requiring disposal in a licensed LLRW disposal facility. The projections vary with the changing business plans of the radioactive materials users.

Table 4-8
Actual and Projected LLRW Volume Shipped for Disposal 1989-1995
(cubic feet per year)

Generator Category	Actual				Projected		
	1989	1990	1991	1992	1993	1994	1995
Academic	2,407	1,863	1,410	1,276	818	716	684
Commercial	35,950	16,681	21,646	70,935	35,203	9,984	9,190
Government	609	1,002	14	32,310	78,004	8	12
Health	2,116	3,288	1,471	978	1,338	1,353	1,346
Utility	17,633	19,406	18,145	13,505	13,655	22,780	10,225
Total	58,715	42,240	42,686	119,004	129,018	34,841	21,457

Source: Massachusetts Low-Level Radioactive Waste Management Board. 1990, 1991, and 1992 Massachusetts Low-Level Radioactive Waste Survey Reports. Boston, MA, November, 1991; November, 1992; and October, 1993.

Figure 4-B
Actual and Projected LLRW Volume Shipped for Disposal 1989-1995
(thousands of cubic feet)



Source: Massachusetts Low-Level Radioactive Waste Management Board, 1993.

Tables 4-9 through 4-11 break down volume data by three of the four disposal classes used by the NRC and the Commonwealth. The four classes are:

Class A waste is characterized by their low concentrations of long-lived radionuclides and concentrations of short-lived radionuclides that will decay to acceptable levels within a 100-year institutional control period, when a disposal facility is maintained after closure. These concentration limits, specified in 10 CFR 61, have been calculated on the basis of acceptable dose limits to an inadvertent intruder who might

Table 4-9
Actual and Projected Class A LLRW Volume Shipped for Disposal 1989-1995
(cubic feet per year)

	Actual				Projected		
Generator Category	1989	1990	1991	1992	1993	1994	1995
Academic	2,407	1,863	1,410	1,276	818	716	684
Commercial	35,852	16,471	21,449	70,696	35,143	9,894	9,103
Government	609	1,002	14	32,310	78,004	8	12
Health	2,112	3,283	1,469	978	1,339	1,353	1,346
Utility	16,484	19,081	17,438	13,138	12,598	13,153	9,868
Total	57,464	41,700	41,780	118,397	127,902	25,124	21,013

Source: Massachusetts Low-Level Radioactive Waste Management Board. 1990, 1991, and 1992 Massachusetts Low-Level Radioactive Waste Survey Reports. Boston, MA, November, 1991; November, 1992; and October, 1993.

occupy the disposal site and encounter waste after this time.

Class B is the next level of wastes that could represent a potential hazard to an inadvertent intruder without additional protective measures, since they contain higher levels of short-lived radionuclides. They must meet the NRC's minimum stability requirements so that the waste forms or containers can "maintain gross physical properties and identity, over 300 years" [10 CFR 61.7(b)(3)], thus limiting the exposure to a potential intruder.

Table 4-10
Actual and Projected Class B LLRW Volume Shipped for Disposal 1989-1995
(cubic feet per year)

Generator Category	Actual				Projected		
	1989	1990	1991	1992	1993	1994	1995
Academic	0	0	0	0	0	0	0
Commercial	98	210	183	105	60	90	60
Government	0	0	0	0	0	0	0
Health	4	5	1	0	0	0	0
Utility	1,149	325	202	132	132	252	132
Total	1,251	540	386	237	192	342	192

Source: Massachusetts Low-Level Radioactive Waste Management Board. 1990, 1991, and 1992 Massachusetts Low-Level Radioactive Waste Survey Reports. Boston, MA, November, 1991; November, 1992; and October, 1993.

Class C wastes are wastes that, due to their greater concentrations of long-lived or short-lived radionuclides, must meet more stringent waste form requirements to ensure stability, and must be disposed of in such a way to protect the inadvertent intruder for a longer period of time. These wastes must meet

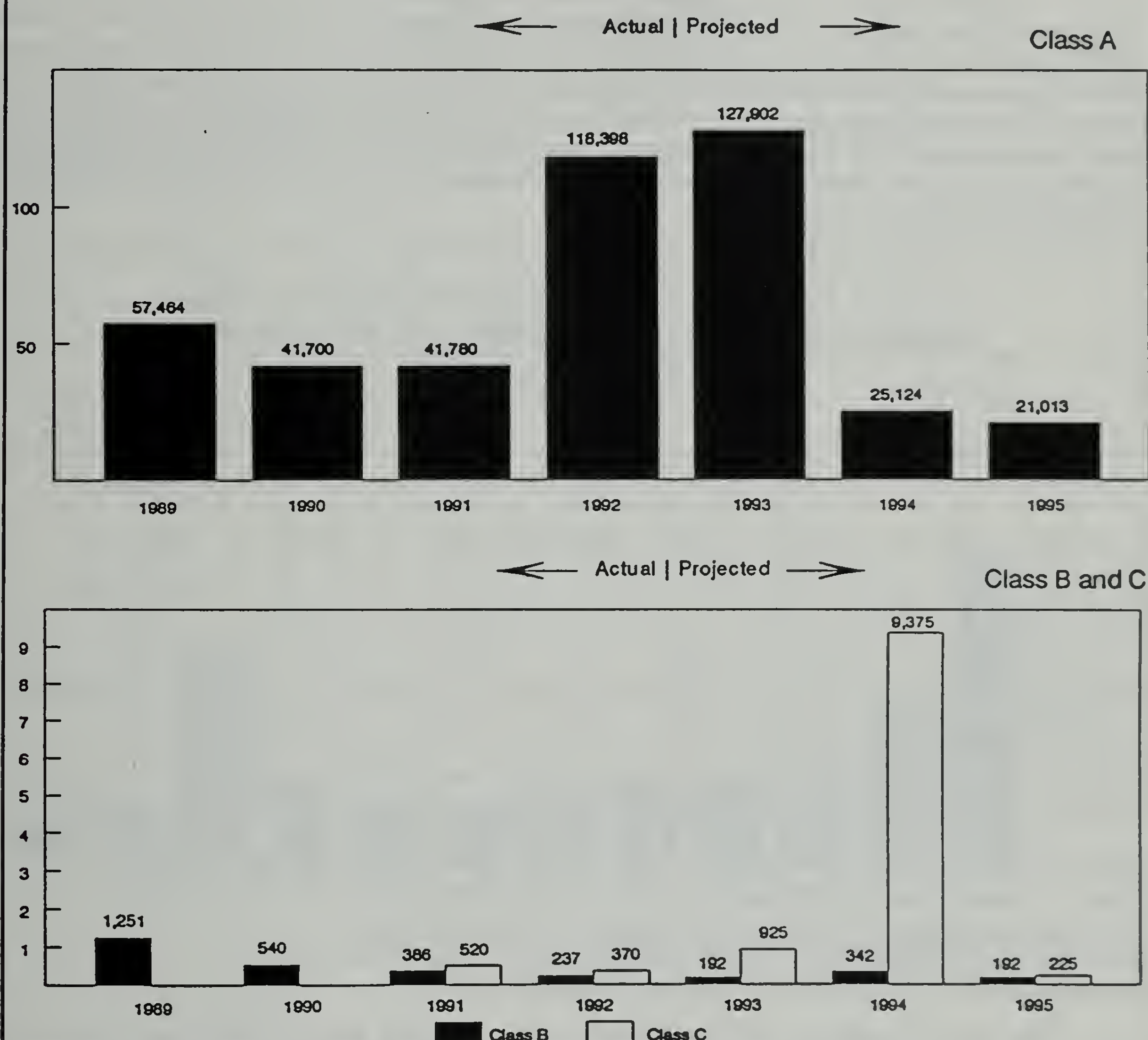
Table 4-11
Actual and Projected Class C LLRW Volume Shipped for Disposal 1989-1995
(cubic feet per year)

Generator Category	Actual				Projected		
	1989	1990	1991	1992	1993	1994	1995
Academic	0	0	0	0	0	0	0
Commercial	0	0	15	135	0	0	0
Government	0	0	0	0	0	0	0
Health	0	0	0	0	0	0	0
Utility	0	0	505	235	925	9,375	225
Total	0	0	520	370	925	9,375	225

Source: Massachusetts Low-Level Radioactive Waste Management Board. 1990, 1991, and 1992 Massachusetts Low-Level Radioactive Waste Survey Reports. Boston, MA, November, 1991; November, 1992; and October, 1993.

the stability requirements for form or container (300 years) and must be disposed of in a manner which protects against inadvertent intrusion for at least 500 years. [10 CFR 61.52(a)(2)]

Figure 4-C
Actual and Projected Class A, B, C LLRW Volume Shipped for Disposal 1989-1995
(thousands of cubic feet)



Source: Massachusetts Low-Level Radioactive Waste Management Board, 1993.

Greater than Class C (GTCC) are wastes with concentrations of radioactive isotopes that generally make them unacceptable for the types of disposal used for Classes A, B, and C. GTCC wastes continue to be the responsibility of the federal government, not the states.

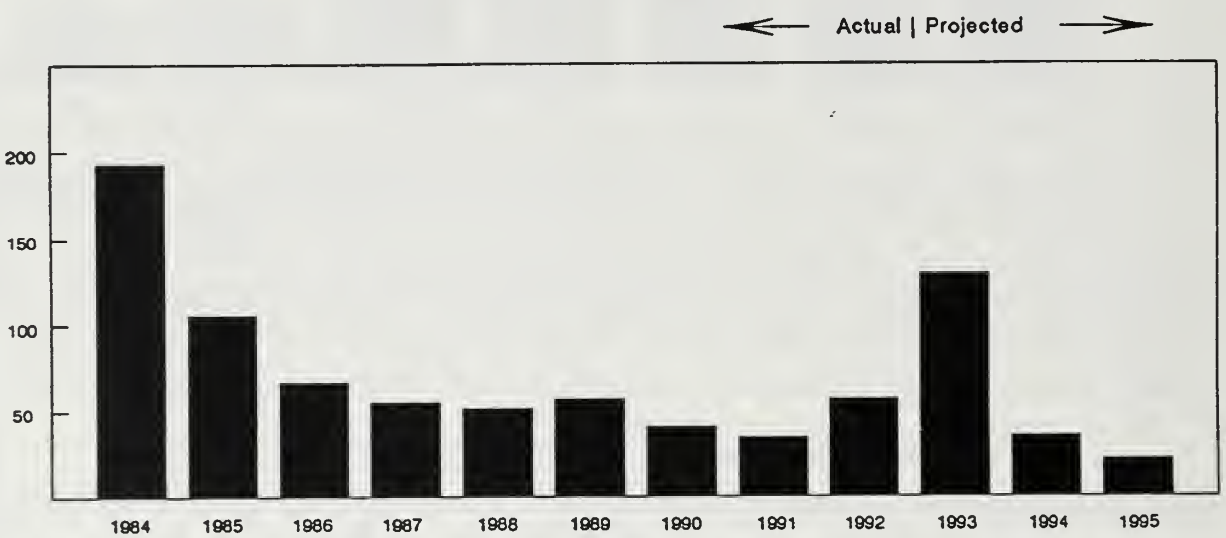
A table with GTCC waste information is not included because of the small amount of this type of waste. In 1989 only one cubic foot of GTCC waste was shipped from a generator. This waste was treated

to reduce the radionuclide concentration so the waste could be disposed of as Class B waste. For the years 1992-1995, no GTCC waste is predicted to be disposed of.

Figure 4-C illustrates graphically the composition of LLRW in Massachusetts. Class A, the category containing the lowest concentrations of long-lived radionuclides, is shown to dominate the LLRW stream now and in the future, representing more than 95% of the total waste stream requiring disposal.

The trends shown on the preceding tables and figures represent a continuation of the overall reduction of LLRW shipped for disposal by Massachusetts generators during the last decade, as illustrated in Figure 4-D. The rise in LLRW shipments for disposal in 1992 resulted from decommissioning projects at Texas Instruments and Watertown Arsenal. The projected high volume of waste anticipated in 1993 results from the decommissioning of these two facilities, as well as Yankee Rowe. Based on survey data, and other information supplied by the generators, the Management Board has predicted that the annual Massachusetts LLRW volume requiring disposal in a licensed LLRW disposal facility will level off at approximately 20,000 to 25,000 cubic feet by the mid-1990s.

Figure 4-D
Historical and Projected LLRW Volume Shipped for Disposal 1984-1995
(thousands of cubic feet)



Source: Massachusetts Low-Level Radioactive Waste Management Board, 1993.

The Yankee Atomic Electric plant in Rowe, Massachusetts, was voluntarily shut down in October, 1991, and the process to begin dismantling and decommissioning was announced in February, 1992. While the Yankee decommissioning plan is being finalized, which will require approval by NRC, Yankee is removing as much LLRW as possible, to take advantage of the available disposal site at Barnwell, South Carolina. During 1992, Yankee shipped 115 cubic feet of irradiated reactor hardware (metals exposed to neutrons in the reactor core), containing 32,080 curies of radioactivity. The total volume of LLRW estimated by Yankee Atomic to be generated from their decommissioning activities is 95,000 cubic feet.

Similarly, Boston Edison Company has projected that the decommissioning of the Pilgrim Nuclear Power Station in Plymouth, Massachusetts, will produce approximately 288,000 cubic feet of LLRW requiring

disposal, when that facility is decommissioned.[11]

LLRW from the decommissioning of other RAM user facilities can also be expected in the future, although the quantities from any individual facility are not expected to approach the volumes estimated for the two power reactors. For planning purposes, the Board has estimated that total decommissioning waste volumes that might be expected in the years 2000-2029 to be approximately 450,000 cubic feet. Additional information about decommissioning volume estimates can be found in Chapter 14.

Projections of Radioactivity

Unlike the projection of an equalized level of future LLRW volumes, the projections of radioactivity in the waste show a fluctuation over the same period. Table 4-12 and Figure 4-E represent four years of reported data and three years of generator projections on the amount of radioactivity, measured in curies, contained in the LLRW.

Table 4-12
Actual and Projected Radioactivity Shipped for Disposal 1989-1995
(curies per year)

Generator Category	Actual				Projected		
	1989	1990	1991	1992	1993	1994	1995
Academic	14	12	36	12	3	3	3
Commercial	56,853	110,389	31,626	43,578	32,738	47,860	32,060
Government	12	2	1	76	<0.1	<0.1	<0.1
Health	13	8	71	7	0.4	0.4	0.4
Utility	300	671	797	32,690	147,626	196,324	50,600
Total	57,192	111,082	32,531	76,363	180,367	244,187	82,663

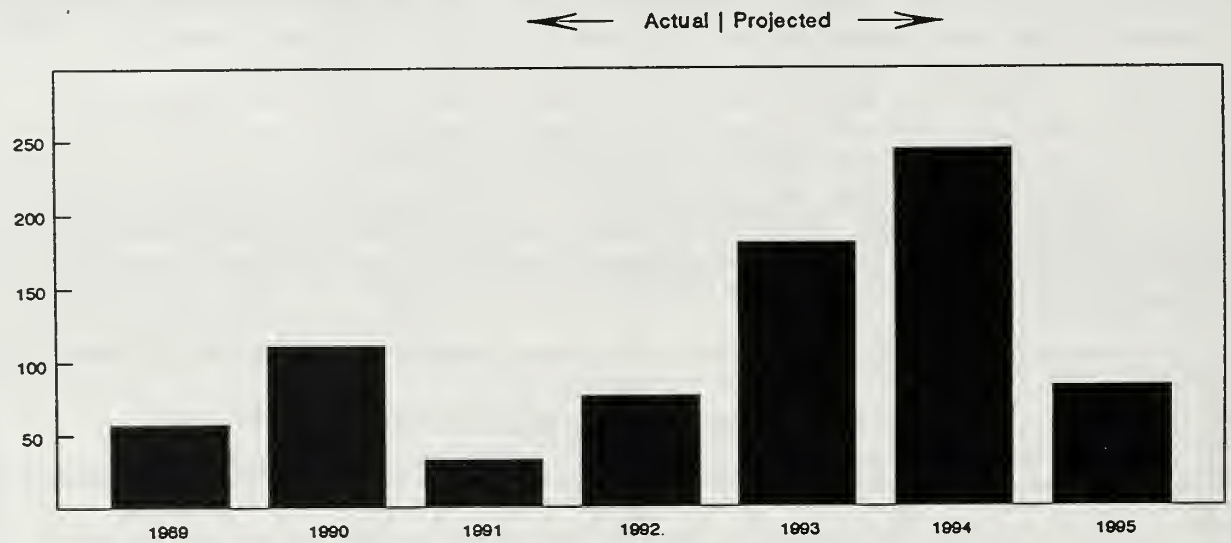
Source: Massachusetts Low-Level Radioactive Waste Management Board. 1990, 1991, and 1992 Massachusetts Low-Level Radioactive Waste Survey Reports. Boston, MA, November, 1991; November, 1992; and October, 1993.

The fluctuations in the radioactivity of the waste do not have any relationship to the total volumes of LLRW requiring disposal. The total radioactivity in 1989 was only half the radioactivity level reported for 1990, although total waste volume dropped from 58,715 cubic feet to 42,240 cubic feet that year. In the following year, 1991, waste volume remained almost constant; however, radioactivity plunged to 32,531 curies. For 1992, when 119,004 cubic feet of LLRW were shipped for disposal, 76,363 curies of radioactivity were contained in that waste.

The Management Board estimates that the total radioactivity of LLRW requiring disposal will continue to fluctuate in the future, as demand for products and services utilizing radioactive materials ebbs and flows with changing economic conditions and expanding medical research and biotechnology enterprises in the

[11] The Pilgrim Station license expires in the year 2012. Boston Edison could close the plant early, as did Yankee Atomic; it could close on the scheduled license expiration date of 2012; or it could seek approval of a license extension. Company officials indicate it is too soon to make any decision about the end date of Pilgrim's operation, and the period of decommissioning.

Figure 4-E
Actual and Projected Radioactivity Shipped for Disposal 1989-1995
(thousands of curies)



Source: Massachusetts Low-Level Radioactive Waste Management Board, 1993.

state. The Board uses its annual surveys to monitor this projection.

LLRW Volume Managed by Storage for Decay

The survey data shows a treatment practice that is used extensively by LLRW generators in Massachusetts and elsewhere. This treatment practice is called "storage for decay," and refers to a procedure in which LLRW with a relatively short half-life is held for natural radioactive decay in compliance with federal and state regulations. At the end of the storage period, the radioactivity has reduced to background levels, allowing it to be disposed of as non-radioactive trash.

Storage for decay is practical for waste that contains radionuclides with relatively short half-lives. A rule of thumb has been that after a decay time of approximately 10 half-lives, the initial activity will have decayed sufficiently to allow disposal of this material with other solid waste. This decay period, coupled with NRC license limitations on the quantities of materials and LLRW that may be stored on site, limit storage for decay as a management technique to wastes that contain radionuclides with half-lives of less than 60-90 days, based on a three-year storage limit. However many of the isotopes used by commercial and medical generators have half-lives that are much less than 60-90 days, and therefore, storage for decay is a common practice.[12] Table 4-13 indicates the continuing trend towards storage for decay management. The totals show that waste stored for decay is comparable in volume to waste shipped for disposal to licensed LLRW facilities.

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[12] The NRC has indicated that it will allow on-site storage for up to five years, if a licensee can demonstrate that no licensed LLRW disposal site is available. This new NRC guideline could allow LLRW generators to store for decay radionuclides with half-lives as long as 180 days.

Generators who practice storage for decay must store their waste in suitable containers within a designated area, and ensure that exposure limits specified in NRC regulations are complied with.

Table 4-13
Actual and Projected Volume of LLRW in Storage for Decay 1989-1995
(cubic feet per year)

Generator Category	Actual				Projected		
	1989	1990	1991	1992	1993	1994	1995
Academic	10,063	5,309	7,119	7,786	6,469	6,674	6,879
Commercial	22,469	5,753	18,010	18,108	13,314	13,574	13,637
Government	21	14,490	37	33	8	8	8
Health	9,509	1,027	13,053	15,302	12,000	12,465	12,432
Utility	0	0	0	0	0	0	0
Total	42,053	26,579	38,219	41,229	31,791	32,721	32,956

Source: Massachusetts Low-Level Radioactive Waste Management Board. 1990, 1991, and 1992 Massachusetts Low-Level Radioactive Waste Survey Reports. Boston, MA, November, 1991; November, 1992; and October, 1993.

Mixed LLRW Volume Stored On-Site for Future Off-Site Disposal

One of the sections of the annual survey form requests information regarding all LLRW stored on site for future off-site disposal. This information aids the Management Board in evaluating the sizes of any centralized storage or disposal facilities as part of its deliberations on the need to site either or both such facilities in the Commonwealth, and in connection with the Board's discussions with other states about possible outside-Massachusetts disposal solutions. The Board reviews data on waste shipped for disposal, data on waste in storage for future disposal, and information about LLRW which may be removed from old burial sites[13] during present or future clean-up activities.

Table 4-14 shows the volume of mixed waste placed in storage during 1989-1992. Mixed waste is LLRW which is contaminated with, or exhibits the characteristics of, toxic chemical "hazardous" waste. Because federal law assigning LLRW management and disposal responsibility to each of the 50 states includes mixed waste, Massachusetts must find disposal solutions for this material. The Commonwealth has joined other states in requesting that the DOE provide for mixed waste disposal, since the vast majority of mixed waste produced in the United States comes from DOE. Several states that have identified sites for new LLRW disposal facilities, including California and Nebraska, are not building mixed waste disposal units, in the hope that a DOE solution will occur.

Additional information on mixed waste can be found in Chapter 8.

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[13] Prior to the early 1960's, when the first LLRW site opened in Beatty, Nevada, for use by commercial (non-federal government) LLRW generators, the Atomic Energy Commission (the predecessor of the NRC) allowed disposal of certain radioactive waste by burial at the site where the waste was produced. Some of these old sites have been identified in Massachusetts, and are described in Chapter 14. Depending upon if, and when, any of the LLRW in these sites is removed, it may become the State's responsibility to arrange for its disposal.

Table 4-14 Mixed LLRW Placed in Storage for Future Off-Site Disposal 1989-1992 (cubic feet)				
Generator Category	Year			
	1989	1990	1991	1992
Academic	1,185	[illegible]	31	45
Commercial	11,488	519	125	292
Government	0	0	0	0
Health	1,475	34	17	15
Utility	158	0	0	150
Total	14,306	576	173	502
Source: Massachusetts Low-Level Radioactive Waste Management Board				

4.6 Inventory of Massachusetts LLRW Generators

The Massachusetts LLRW management law, Chapter 111H, requires this Management Plan to include an inventory of all Massachusetts generators, including information on their location, products, services, clinical procedures, and teaching and research activities; assessment of the economic impact to the Commonwealth; the volume, characteristics, and curies of their current and projected LLRW streams; and management practices involving source and waste volume minimization, on-site storage, treatment, packaging, and transportation. Much of these data have been presented in earlier sections of this chapter. Additional Information about Massachusetts LLRW generators' storage, treatment, and disposal practices, transportation, and other LLRW-related activities appears in other chapters of this Plan.

Appendix F at the end of this volume lists LLRW survey recipients, along with Information on their location; individual volumes generated (if any); radioactivity; principal packages used; number of shipments in 1992; and, generally, their products, services, clinical procedures, and teaching or research activities. The annual Management Board LLRW survey provides the most up-to-date Information to fulfill the generator inventory requirement of the law. Copies of the annual survey are available from the Management Board, 100 Cambridge Street, Room 903, Boston, MA, 02202.

4.7 Economic Impacts of Radioactive Materials Use

Another requirement of state law which is incorporated into this Management Plan is the provision for an evaluation of the economic benefit to the Commonwealth of all the various activities involving the use of radioactive materials. [Chapter 111H, sec. 12(b))3)]

In order to collect this information, in 1991, radioactive materials users were surveyed relative to:

- the revenue which each company or institution using radioactive materials would have lost if it

had been unable to use these materials in 1991;

- the number of employees directly involved in the use of radioactive materials; and
- those employees that are indirectly involved in radioactive materials use.

Survey responses are summarized in Table 4-15. They indicate that 16,711 employees are "directly" involved in the use of radioactive materials and the possible generation of LLRW as a by-product of that use. An additional 19,345 people work for companies or institutions that use these materials. The revenues which would have been lost if radioactive materials could not be utilized are highest among the commercial category of users, exceeding $1.7 billion dollars. Together, all users responding to the survey reported revenues of approximately $3.035 billion dollars through the use of radioactive materials.[14] This amount equals approximately 2.0% of the Gross State Product for 1989, the last year such information was available.

Table 4-15
Employment and Revenues Reported by Radioactive Materials Users-By Generator Category

Generator Category	Direct Employees	Indirect Employees	Revenues
Academic	5,456	3,734	$419,073,298
Commercial	5,199	6,206	$1,863,195,959
Government	7	20	$440,000
Health	4,389	5,553	$349,279,248
Utility	1,660	3,832	$403,492,000
Total	16,711	19,345	$3,035,480,505

Source: Massachusetts Low-Level Radioactive Waste Management Board. 1991 Massachusetts Low-Level Radioactive Waste Survey Report. Boston, MA, November, 1992.

Table 4-16 breaks down the revenues related to radioactive materials use and the number of organizations (and employees) involved by the volume shipped for disposal during 1991. Figure 4-F illustrates graphically the number of radioactive materials users versus the potential loss of revenues if those materials were unavailable.

Economic benefits to the Commonwealth fall into a number of areas other than employment and revenues directly attributable to radioactive materials. Not all groupings of "economic benefits" were requested in the survey. For example, data was not solicited on the portion of the total economic benefit resulting from tax revenues paid to state and local governments to help compensate for governmental services. In addition, information was not requested regarding the reinvestment of funds in these companies and institutions to encourage growth and expansion, or the profits shared by shareholders and employees to expand the level of dollars available to purchase other goods and services, or to provide further financial investment opportunities.

Other benefits to society, which are hard to quantify in monetary terms, nonetheless need to be

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14 The economic information was collected through a supplement to the 1991 survey, and only 64% of the total group receiving the survey instrument responded to this section. Were the response higher, it is assumed that the data would show larger revenues and greater numbers of involved employees.

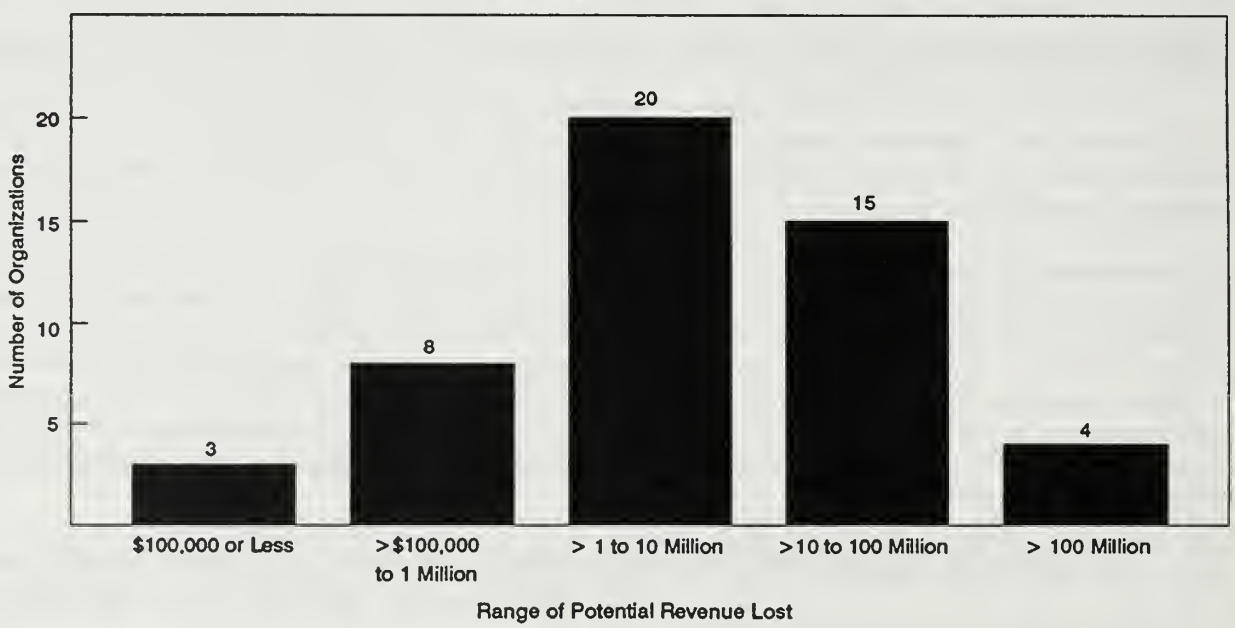
considered in this analysis. These include: the significant medical gains achieved from the use of these materials for diagnostic and therapeutic activities, such as radioimmunoassay tests and the treatment of mental retardation in newborns; the advances in medical research to find cures for cancer, multiple sclerosis and AIDS; many consumer goods in demand today, including smoke alarms, canned soft drinks, and sterilized plastics; the assurance of the quality of welds and the detection of flaws; and the ability to date and verify prehistoric and antique objects such as fossils at science museums and paintings at the Museum of Fine Arts.

Table 4-16
Employment and Revenues Reported by Radioactive Materials Users - By Volume Shipped for Disposal

Volume Shipped (cubic feet)	Number of Organizations	Direct Employees	Indirect Employees	Revenues
0 to 15	229	3,294	6,814	$686,439,989
>15 to 50	26	2,405	2,058	$271,850,516
>50 to 100	11	3,145	2,282	$334,350,000
>100	2[illegible]	7,867	8,191	$1,742,840,000
Total	288	16,711	19,345	$3,035,480,505

Source: Massachusetts Low-Level Radioactive Waste Management Board. 1991 Massachusetts Low-Level Radioactive Waste Survey Report. Boston, MA, November, 1992.

Figure 4-F
Number of Radioactive Materials Users vs. Potential Revenue Lost



Source: Massachusetts Low-Level Radioactive Waste Management Board

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Chapter 5: Public Participation: A Cornerstone of LLRW Management

5.1 Introduction

Chapter 1 describes this Management Plan as a "living document," which is intended to be re-examined and modified according to the needs of the Commonwealth and its citizens.

There are many reasons that the Plan will be routinely reviewed and reconsidered. One reason may be due to a change of opinion by officials in other states, which may allow additional out-of-state low-level radioactive waste (LLRW) disposal capacity to become available to Massachusetts generators. Moreover, Congress may amend federal LLRW laws to alter the states' responsibility for managing and disposing of LLRW, thereby requiring changes in state LLRW policy.

None of the reasons, however, is more intrinsically related to a principle embodied in the State's LLRW management law than the reason of ensuring continuous public involvement in LLRW management policy. Public participation is a necessary component in this review, and in all of the other activities relating to the State's responsibility over LLRW management.

This chapter describes the importance of public interaction in the development and implementation of state policy to manage and dispose of the LLRW produced by approximately 450 academic, medical, government, commercial and utility licensed users of radioactive materials.[1] In addition, the chapter describes the explicit requirements for citizen participation contained in Massachusetts General Laws c.111H (Chapter 111H), the State's Low-Level Radioactive Waste Management Act; and offers recommendations, including a "Public Participation Plan," to ensure meaningful citizen involvement and opinion in the management of LLRW in Massachusetts.

Finally, this chapter describes public participation under two very different scenarios of LLRW management: (1) the public's involvement in LLRW management if the Commonwealth does <u>not</u> site an LLRW storage, treatment, or disposal facility within Massachusetts, and (2) the public participation involved if such a facility <u>is</u> voted to be sited.

5.2 Public Participation: What it Is, and Why it is Important

The phrase "public participation" can be found throughout Chapter 111H. These references are part of the State's LLRW management law to ensure that citizens have the <u>right</u> to share in the many forms of public interaction involved in LLRW management. The statute requires that a full-time Public Participation

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[1] The number of licensed users of radioactive materials varies yearly in Massachusetts as companies, universities, and other "users" acquire additional licenses, or terminate old ones.

Coordinator must be employed by the Management Board "to encourage and facilitate the participation of interested persons in all of the processes established in or pursuant to this chapter."

The Public Participation Coordinator is the key link between the Commonwealth's LLRW management policy and the public. The Coordinator's role is to ensure that the fullest level of public participation possible is implemented in the development of LLRW policy. Besides "encouraging and facilitating" citizen interaction, section 6 of Chapter 111H also requires the Public Participation Coordinator:

- to make recommendations to the Management Board, the Department of Public Health (DPH) and the Department of Environmental Protection (DEP) "concerning the implementation of programs to assure appropriate public participation" in connection with these agencies' responsibilities under Chapter 111H;

- to publicize throughout the Commonwealth the State's LLRW Management Plan;

- to announce throughout the Commonwealth and to conduct continuing public informational programs on the use of radioactive materials, the characteristics and nature of LLRW, technologies relating to LLRW storage, treatment and disposal, and the possible hazards associated with LLRW, especially if it is improperly managed;

- to establish a Public Participation Advisory Committee comprised of individuals representing the range of public opinion concerning LLRW, and LLRW management, who will provide advice and assistance to the Public Participation Coordinator on establishing and conducting public informational programs; and

- if a decision is made to site an LLRW storage, treatment, or disposal facility within Massachusetts, to encourage and facilitate the participation of interested individuals in site identification and development activities, in environmental review and licensing proceedings, and in the review of facility operations.

The role of public participation in LLRW management does not apply just in the case of a Management Board decision to site a storage, treatment, or disposal facility within the State. Rather, public participation is of central importance, no matter how the siting question is answered.

"Public participation" has different meanings to different people. Some interpret this concept only as "public relations," or the "selling" to the public of ideas and decisions already decided upon by others. Public relations campaigns are <u>not</u> two-way communications, or <u>not</u> two-way decision-making. Public relations is <u>not</u> what is specified in Chapter 111H.

While the phrase "public participation" is not defined in Chapter 111H, its intent is clear from the description of the Public Participation Coordinator's responsibilities, summarized above.

Elizabeth Peele, a researcher for the U.S. Department of Energy (DOE) who has written and lectured extensively on public participation, defines this concept in the exact terms that are embodied in Chapter 111H. She describes public participation as "any interactive process of citizen involvement in decision-making involving a bona fide effort to achieve consensus among stake-holders."[2] Her recommendations of important public participation factors include:

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[2] Peele, Elizabeth. "Beyond the NIMBY Impasse II: Public Participation in an Age of Distrust." U.S. Department of Energy, Oak Ridge National Laboratory, Oak Ridge, TN, 1988.

- a citizen or expert task force;
- federal or state funding of public participation activities;
- interactive public participation with a responsive state agency;
- adequate and timely information available;
- logistical support of the citizen task force;
- in-house technical expertise;
- if facility siting is involved, two-way communication during any site assessment process; confidence by the citizen task force in its own understanding of the siting proposal and the local impacts; and negotiation of incentives, compensation, and mitigation measures.[3]

As stated, each of these factors is contained within Chapter 111H to guarantee that the public plays an "active," rather than simply a "reactive," role in LLRW management.

The Importance of Public Participation

Public participation is especially critical in a state such as Massachusetts, which has a government founded on the principles of liberty, democracy, and self-determination. Those principles are embodied in the strong traditions of local home rule that have successfully provided elected and appointed volunteers to run city and town governments for centuries. Nowhere else in the United States, outside New England, is the principle of public participation exhibited more than in the daily operations of Massachusetts local government.

Public participation is important in the management of LLRW to ensure that the state and federal agencies assigned responsibility for this activity are accountable. Public participation will help to develop trust between citizens and government agencies mandated to provide long-term LLRW disposal. It will ensure that the concerns of the people who are most affected by important management decisions are heard and addressed. Moreover, it will provide a framework for citizens, state officials, and radioactive materials users to discuss the costs and benefits of LLRW management, and to evaluate the activities of all interested parties.

Peter M. Sandman, Director of the Environmental Communication Research Program at Rutgers University and a nationally-known author of risk communication publications, believes in the importance of public participation, especially in connection with any potentially controversial government action. He says that citizen involvement is important because:

(a) people are entitled to make decisions about issues that directly affect their lives;

(b) input from the community can help a government agency make better decisions;

(c) involvement in the process leads to greater understanding of -- and more appropriate reaction to -- a particular risk;

(d) those who are affected by a problem bring different variables to the problem-solving equation;

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[3] Ibid.

Figure 5-A
Ladder of Citizen Participation

Citizen Power	Citizens act without communicating with government	• volunteer fire department; • citizen investigation; • citizen development and implementation programs
Power Sharing	Citizens and government solve problems together	• funding of citizen groups to hire technical consultants and/or implement projects; • citizen oversight and monitoring; • meetings called jointly by government and citizen groups
Consult 2	Government asks citizens for limited input and intends to listen	• citizen advisory committees; • informal meetings; • on-going dialogue; • some public hearings
Consult 1	Government asks citizens for limited input and would prefer not to listen	• most public hearings; • most requests for responses to formal proposals; • pro-forma meetings and advisory committees
Inform	Government talks; citizens listen	• some public meetings; • press releases and other informational strategies; newsletters, brochures, etc.
Government Power	Government acts without communicating with citizens	• some investigations; • legal and enforcement actions

Source: Sandman, Peter, C. Chess and B. Hance. "Improving Dialogue with Communities: A Short guide for Government Risk Communication." Environmental Communication Research Program, Rutgers University, New Brunswick, NJ, 1988.

and

(e) cooperation increases credibility.[4]

Sandman describes the various forms of citizen participation in a "ladder," shown in Figure 5-A. He urges government agencies to place interaction with the public at the highest rung possible, and to articulate clearly to the public the level of its participatory role.

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[4] Sandman, Peter, C. Chess and B. Hance. "Improving Dialogue with Communities: A Short Guide For Government Risk Communication." Environmental Communication Research Program, Rutgers University, New Brunswick, NJ, 1988.

Public Participation in Siting Activities

If the Commonwealth determines that a storage, treatment, or disposal facility must be sited, the importance of public participation must be stressed. Because some instances in which government has failed to protect the environment are well known, a level of distrust exists regarding government actions. The public must have confidence in the fairness of public policy development -- both in the way policy decisions are made, and in their outcome. While people in a site community may never be pleased that a facility is to be sited in their town, their involvement in the process will help them to understand and appreciate how the decision was made.

If a facility siting determination is made, public participation is critically important for a number of other reasons. It:

- aids site communities in protecting local values, preserving their basic political rights, and ensuring that their concerns about health and safety are addressed;
- enables citizens to recruit their own technical and scientific experts to review a proposed project;
- allows citizens to gain the necessary information about siting activities in order to be fully informed and able to evaluate siting activities rationally;
- helps government officials and citizens to identify their collective goals, limit their differences, and move ahead to locate facility sites in acceptable places;
- enables citizens to exercise oversight in facility site identification, development, and operations;
- opens facility operations to public scrutiny, and subjects facility safety practices to close community review;
- provides a focus for the development and implementation of effective source and LLRW volume reduction and elimination policies, mitigation standards, and economic benefits;
- enhances the effectiveness of risk management decisions; and
- ensures that community values are identified and protected.

Because federal law transfers responsibility over LLRW management to the states, public participation provides mechanisms to ensure that the public is informed of the Commonwealth's choices for long-term LLRW management.

5.3 Public Participation Provisions of Chapter 111H

Chapter 111H assigned new responsibilities to existing state agencies and created certain new entities, all for purposes of LLRW management. Each entity performs a portion of the public participation requirements of the Act.

This section describes the explicit provisions for public participation which are contained in Chapter 111H. Because those provisions cover LLRW management in the two main categories of LLRW policy: (1) "non-siting" policy decisions and (2) "siting" determinations, the discussion in this section is organized

according to those categories. Table 5-1 and 5-2 list all Chapter 111H requirements where official notice must be given, where public comment and review is sought, and where public meetings[5] are held to further identify local suggestions and concerns. Table 5-1 pertains to "non-siting" related activities, and Table 5-2 refers to those provisions of Chapter 111H involving facility "siting."

Table 5-1
Requirements for Public Notice, Public Comment and Review, and Public Meetings under "Non-Siting" Scenario

Activity	Public Notice	Public Comment and Review	Public Meeting
Draft Management Plan	X	X	X
Draft regulations to implement Management Plan	X	X	X
Draft source/volume minimization regulations	X	X	X
Draft storage for decay regulations	X	X	X
Draft site selection criteria regulations	X	X	X
Draft storage, treatment or disposal facility licensing, development, operation, closure, post closure observation and maintenance, and institutional control regulations	X	X	X
Draft operator selection criteria regulations	X	X	X

X = Public notice and public meetings for comment and review given pursuant to M.G.L. c.30A or an equivalent procedure

Source: M.G.L. c.111H, Low-Level Radioactive Waste Management Act, 1987.

The requirements explicitly stated in Chapter 111H may be amplified with additional public participation activities at the discretion of any of the state agencies involved in LLRW management. Recommendations in section 5.4 of this chapter expand the statutory citizen participation requirements.

"Non-Siting" Public Participation Requirements

Public Participation Coordinator. The principal function of the Public Participation Coordinator is to facilitate citizen involvement in all the processes related to the State's management of LLRW. Those processes include:

- establishing and working with a Public Participation Advisory Committee, which advises and assists in the development of public informational programs relating to radioactive materials use and LLRW generation;

[5] Chapter 111H defines a "public meeting" as a meeting which satisfies the public hearing requirements of the State's Administrative Procedures Act, in which state agencies present information, respond to inquiries, and hear testimony of interested persons. Public meetings allow two-way communications, whereas the traditional "public hearing" provides only one-way discussion. The terms "public meeting" and "public hearing" are used interchangeably throughout this Management Plan, and always refer to the "public meeting" definition.

- assuring that citizens are informed about and encouraged to participate in the public meetings of all state agencies involved in LLRW management;

- guaranteeing the public's participation in the development of an LLRW Management Plan, which is intended to set the direction of public policy in this area for years to come;

- ensuring that regulations developed by all involved state agencies are available for review in draft form, prior to their adoption.

- working with citizens, local officials, affiliations of radioactive materials users, and others to ensure that adequate information is available prior to statutorily-mandated public hearings to obtain public comment on the draft LLRW Management Plan, the LLRW minimization regulations and all other regulatory proposals pertaining to LLRW management; and

- facilitating the preparation and execution of the statewide public hearings on the LLRW Management Plan and regulations at the end of Phase I of Chapter 111H.[6]

Low-Level Radioactive Waste Management Board. The Management Board is the lead agency under Chapter 111H responsible for "planning and effecting the management of low-level radioactive waste in the Commonwealth." Unlike many boards and commissions whose members are appointed to represent the special interests of certain affected groups, the Management Board is comprised of people appointed by the Governor whose experience, background, and professional training in the areas of:

(1) public administration,

(2) engineering,

(3) radiological health,

(4) business management, and

(5) environmental protection,

indicates that they can act **"in the public interest."** [section 2(b)[7]]

In order to ensure that the "public interests" of the Board are fairly and equitably represented in major decisions, the statute requires a two-thirds affirmative vote for certain critical Board actions, such as decisions relating to siting. The law also requires the Board to give notice to the public **prior** to voting on certain actions.

All Management Board meetings must follow the provisions of the State's Open Meeting Law, Massachusetts General Laws c. 30A, section 11A 1/2, to allow the public to attend and participate. Minutes are produced for all meetings, and are available to the public. [section 3(d)]

Other statutory requirements to ensure public participation by the Management Board include:

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[6] Phase 1 of Chapter 111H is the "planning" phase. Please refer to Chapter 2, section 2.3, for a discussion of each phase of Chapter 111H.

[7] All sections referenced in this part of the chapter without mention of a statute refer to sections of Chapter 111H.

- conducting continuing public participation and informational programs; [section 4(a)(6)]

- issuing an annual report; [section 4(a)(9)]

- providing a detailed report to the Legislature's Committee on Natural Resources on progress in negotiations with other states for the establishment and operation of regional disposal facilities; [St. 1987 c.549, section 6[8]] and

- issuing the Management Plan, its associated regulations and all other Management Board regulations in draft form for a 120-day review period. During that time, the Board must hold a minimum of six public meetings across the state to explain the drafts, and to receive public comment. [section 11(b)]

Department of Public Health (DPH). DPH is obligated to follow requirements similar to the Management Board in ensuring public participation during the completion of its activities under Chapter 111H. All of the regulations that DPH must develop under Phase I, the Planning Phase, must be issued in draft form for public review and comment at the same statewide public meetings of the Management Board. The subjects of the DPH regulations are:

- source and volume minimization;

- storage for decay; and

- storage, treatment, or disposal facility licensure, development, operation, closure, post-closure observation and maintenance, and institutional control.

DPH must also prepare and issue an impact report discussing various issues relating to the last set of regulations listed above. The report is intended to provide information to the public on the thought processes used by DPH in developing its draft facility licensing regulations.

In addition, DPH is required to work with the Public Participation Coordinator in conducting the required statewide public meetings.

Department of Environmental Protection (DEP). DEP, like DPH and the Management Board, must develop its regulations, which include siting criteria and site identification procedures, for issuance in draft form for public review and comment.

DEP must assist the Public Participation Coordinator in scheduling and conducting the mandatory statewide public hearings.

Local Government. Local government officials work with the Public Participation Coordinator, the Management Board, DPH, and other state officials to facilitate community involvement in all the processes related to LLRW management. Local officials have the opportunity to:

- serve on the Public Participation Advisory Committee to advise and assist in the development of public informational programs relating to radioactive materials use and LLRW production; and

- participate in public meetings on LLRW management.

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[8] The aforementioned regional negotiations report is contained in Chapter 6 of this volume of the Management Plan.

Local officials may participate in Management Board meetings, and may comment on:

- the Board's draft regulations and draft Management Plan;
- DPH draft regulations for facility licensing, development, operation, closure, post-closure, institutional control, and waste minimization; and
- DEP draft regulations regarding siting criteria, and guidelines and procedures for the conduct of site selection.

The public. Every aspect of LLRW management involves the public. Citizen participation in "non-siting" LLRW policy areas reaches to the level of "Consult 2" on Sandman's ladder, Figure 5-A. None of the LLRW management regulations, or the Management Plan, may be adopted until the public has had the opportunity to review the drafts and to provide comments.

Citizens representing "the range of public opinion" concerning LLRW or its management may participate in the Public Participation Advisory Committee to advise and assist the Public Participation Coordinator. Citizens may attend all meetings of the Management Board, and join in on the public policy discussions.

"Siting" Public Participation Requirements

A decision to site an LLRW storage, treatment, or disposal facility is a significant one. The activities to implement that decision are bound to heighten public awareness of the State's responsibilities to manage LLRW, and to increase public concern about health, safety, and environmental protection.

For these reasons, Chapter 111H public participation provisions that relate to a "siting" decision are comprehensive and sweeping. Citizen participation occurs at every juncture in the siting process, as shown on Table 5-2. Two-way, interactive communication is required throughout, and many siting elements are handled at the "Power-Sharing" level of Sandman's citizen participation ladder in Figure 5-A. Two important elements of the siting process -- selection of a facility operator and selection of the facility technology -- are at the "Citizen Power" level.

A summary follows of the key public participation activities of each entity involved in LLRW facility siting.

Public Participation Coordinator. In order to inform the public and to encourage and facilitate public participation, the Public Participation Coordinator is responsible for publicizing all plans for the selection of any LLRW storage, treatment, or disposal facility site and site operator, and any proposals to develop, operate, and close such facilities throughout the Commonwealth.

In addition, numerous facility siting sections of Chapter 111H require that the recommendations of the Public Participation Coordinator regarding procedures for citizen involvement "shall be implemented to the extent feasible."

Because of the controversial nature of siting any type of waste facility, the drafters of Chapter 111H were especially deliberate in stressing the need for, and importance of, public participation during Phase II, the Site Selection Phase. In addition to the language mentioned above relative to implementing the Public Participation Coordinator's recommendations to the extent feasible, section 19 of Chapter 111H further provides that the Coordinator's recommendations must:

"ensure appropriate public participation in the site selection process; to ensure that

adequate information concerning the site selection process is available; to facilitate the conduct of public meetings and other opportunities for public review and comment; and to ensure that public concerns are identified and addressed throughout the site selection process."

Table 5-2
Requirements for Public Notice, Public Comment and Review, and Public Meetings under "Siting" Scenario

Activity	Public Notice	Public Review and Comment	Public Meeting
Initiate Site Selection:			
Prior to vote:	X	X	X
After Affirmative vote:	X		
Report identifying possible locations	X, Y	X	X
Draft candidate site identification report	X, Y	X	X
Development of detailed site characterization plan	CSC	X, CSC	X
Conducting studies under detailed site characterization report	X, CSC	X, CSC	X
Draft detailed site characterization report	X, CSC	X, CSC	X
Draft environmental impact report	X, CSC	X, CSC	X
Notification of intent to apply for facility license	X, CSC	CSC	
Issuance by DPH of draft facility license or draft denial	X, CSC	X, CSC	X
Issuance by DPH of annual report evaluating the environmental monitoring program	X	X	X
Management Board approval or denial of operator's fee schedule and waste acceptance criteria	X	X	X
Reopening of a facility if temporarily closed by DPH	X, Y	X	X
Facility closure plan	X, Y	X	X
Draft institutional control plan	X, Y	X	X
Decision by DPH to allow facility license transfer from the operator to the Management Board	X	X	X
Annual DPH report of inspections and supervision of institutional control	X, Y	X	X
Annual Management Board report during institutional control	X, Y	X	X

X = Public notice and public meetings for review and comment given pursuant to M.G.L.c.30A or an equivalent procedure
Y = Public notice given to chief executive officer of a community
CSC = Public notice given to, or review and comment conducted by, the Community Supervisory Committee

Source: M.G.L. c.111H, Low-Level Radioactive Waste Management Act, 1987.

Phase II is divided into numerous procedural steps to ensure that the Management Board, its technical consultants, local officials, and the public slowly but precisely complete an environmental screening of the entire state to eliminate potentially unsuitable siting locations. As each level of screening occurs, with increasingly more detailed environmental review continually to eliminate areas that appear to be inappropriate, the statute requires that reports be issued, the public be notified, and public meetings be held to explain the siting activities described in the reports and to elicit public review and comment. The Public Participation Coordinator will effectuate these citizen involvement activities, if a siting decision is ever made.

Management Board. Before taking a vote to initiate LLRW storage, treatment, or disposal facility siting, the Board must issue a notice of its intent to conduct such a vote no less than 21 days prior to the vote. [section 17(b)]

Upon voting to begin site selection, the Management Board must notify the chief executive officer (CEO) of every municipality in the Commonwealth that the site selection process has begun.[9]

If facility siting is initiated, and if a "superior site"[10] is chosen through the siting process, the size of the Management Board (and its ability to further represent the public interest) is enhanced by the addition of two Board members representing the site community and possibly a neighboring community. As long as that site is in any phase of development, operation, closure, post-closure, or institutional control (see glossary of definitions), those two additional Board members will ensure that community concerns are addressed through their participation on the Board, and the participation of citizens from their communities. [section 2(b)]

Other Chapter 111H requirements to ensure public participation by the Management Board in the event of facility siting include:

- notifying municipalities represented in the reports issued during the process of screening out unsuitable land areas. Public meetings must be held to receive public review and comment;[11] [section 20(b) and (c)]

- establishing a field office in the site community; [section 26(b)]

- maintaining copies of all the records and analyses resulting from the DPH environmental monitoring program at the facility site; [section 36(b)]

- appointing a "resident engineer" to represent the Board and be present at the site daily during

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[9] The "chief executive officer" is the city manager in any city having a manager, the mayor of any other city, the town manager in any town having a town manager, or the chairman of the Board of Selectmen in any other town.

[10] A "superior site" is one which has been chosen by the Management Board, following detailed site characterization spanning a period of four seasons.

[11] For the Report Identifying Possible Locations, [section 20(b)] and the Draft Candidate Sites Identification Report [section 20(c)], Chapter 111H specifically requires the Management Board to notify the CEOs of all communities mentioned. The law defines "possible location" as a parcel of land which has been identified for preliminary investigation and analysis in the initial stages of screening the entire state for suitable facility sites. The Draft Candidate Sites Identification Report is a report which must be issued by the Management Board identifying sites that will undergo detailed, on-site investigation and analysis prior to the selection of any final, "superior" site.

facility construction, to work in cooperation with site community officials to "check, inspect, and report" to the Board about events at the construction site; [section 37]

- participating at public meeting(s) called by DPH to solicit public comment on any plan to close the facility. [section 43(a)] Once DPH accepts the plan, the Board must periodically inspect the operator's implementation of the closure plan, in cooperation with local officials; [section 43(b)]

- issuing a draft plan for institutional control at the appropriate stage of planning for the facility license to be transferred to the Board. The Board must conduct a public meeting on the draft institutional control plan, for public review and comment;[12] [section 46(a)] and

- releasing a report for public review and comment at public meetings each year the facility is in institutional control. [section 47]

Community Supervisory Committee. Community Supervisory Committees (CSCs) are established after candidate sites[13] are identified, but **before** detailed site characterization is initiated, to study, over a year's time, the hydrogeology and other environmental characteristics of these potential sites. CSCs are selected in each candidate site municipality to assist the Management Board in developing the scope of detailed site characterization, as well as to monitor its implementation.

Like the Management Board whose composition includes professionals experienced in a wide range of environmental, business, and radiological health fields, in order to reflect the "public interest," CSC membership is also designed to represent the community's concerns over environmental protection, public health, community values, and local planning and management. [section 21(a)] The CSC is composed of the chief executive officer or his designee; the chairpersons or their designees of the local Conservation Commission, Board of Health, and Planning Board; and three community residents.

The CSCs provide the vehicle for direct citizen involvement and community participation in the siting process. Table 5-3 summarizes the major participatory activities of these local groups, first every CSC appointed by the CEO of the community during the evaluation of the "candidate" sites, and later when the "superior site" is chosen and all CSCs but that representing the superior site cease to function.

Chapter 111H provides that the CSCs serve as the lead local entity during detailed site characterization, while environmental data are being collected to determine which of the candidate sites, if any, may be chosen as the final, "superior," site. Each CSC will receive funds from the Management Board in order to hire consultants for advice on technical matters, and to retain administrative and clerical personnel. [section 21(d)]

The CSCs are responsible to assist the Management Board in developing the plan that will be used to conduct the detailed site characterization for a candidate site. [section 23] As the detailed site characterization studies are being performed, each CSC "shall be kept informed of the progress...; be furnished copies of all data, reports, and memoranda pertaining to said detailed site characterization including raw data, draft reports, and memoranda; and given reasonable opportunity to review and comment

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12 Chapter 111H explicitly provides that "the institutional control period shall not be less than the minimum time required for any low-level radioactive waste present at the site to decay to the maximum concentrations above natural background levels permitted to be released into air or water in unrestricted areas under federal and state law." [section 46(b)]

13 A "candidate site" is a site identified for detailed site characterization as part of the process to select a final, "superior site."

upon all work performed." [section 23(a)] This statutory language will ensure that the CSC receives site characterization data prior to any final siting decisions so that it can participate in evaluating the data and recommending further study or alternative actions.

Once the draft detailed site characterization plan is issued, the CSC will continue to ensure public participation by holding a public meeting jointly with the Management Board to discuss this plan. [section 23(b)]

Table 5-3
Public Participation by the CSCs

Entity involved in Public Participation	Activity	Means of Public Participation
Every CSC	Establishment	To represent the interests of the site community.[1]
Every CSC	Preparing for detailed site characterization	Work with Management Board to develop scope of detailed site characterization program, and to monitor the characterization activities.
Every CSC	During detailed site characterization	CSCs will receive all data, reports, etc. pertaining to site characterization in order to review and comment on the characterization efforts.
"Superior Site ("SS")[2] CSC	Upon selection of a superior site	CSC is expanded to include representatives from neighboring communities, as appropriate.
"SS" CSC	Pick facility developer and operator; negotiate	Interview applicants; negotiate with Operator applicants for compensation and impact payments for site and neighboring communities.
"SS" CSC	Select type of technology to be used at the facility	Work with Management Board to evaluate various technologies; discuss with potential developers. Shallow land burial is prohibited.
"SS" CSC	Comprehensive Operating Contract negotiations	Consult with Management Board regarding contract terms and conditions.

[1] CSCs receive funds from the Management Board to assist them in accomplishing their duties.
[2] A "superior site" is a site selected by the Management Board, after detailed site characterization.

Source: M.G.L. c.111H, Low-Level Radioactive Waste Management Act, 1987.

After a superior site is selected, the CSCs from the candidate sites not chosen are abolished, and the CSC from the superior site community is expanded to include representatives from designated neighboring communities. A "neighboring community" is defined in Chapter 111H as "a community, other than a site community, which, according to the most recent federal census,[14] has at least 20% of its population residing within three miles of any superior site."

The expanded CSC's role moves from advisory to determinative. Chapter 111H authorizes the Superior Site CSC (also called the "CSC" from here forward) to:

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[14] Chapter 111H refers to the "decennial" census for the purpose of determining a "neighboring community," not the federal census. The requirement that the Commonwealth conduct a 10-year census was duplicative of the federal 10-year census, and costly to the state as well. Section 25 of St.1992, c.403, repealed the state decennial census, and replaced all references to it in state law with the federal census.

- interview potential facility operators [section 27(a)], and select the company that will construct and operate the facility from those companies certified by the Management Board to have met the operator selection criteria regulations [section 27(c)];

- negotiate with potential facility operators on issues relating to compensation and impact payments; [section 27(b)];

- select the type of facility technology most suited for the site and the site community.[15] [section 27] The CSC may **not** pick "shallow land burial" as a technology for a disposal facility, since that method of disposal is prohibited by section 16(a) of the law;

- on behalf of the site community, consult with the Management Board negotiating the terms of the comprehensive operating contract; [section 33]

- receive and expend "technical assistance and planning funds provided by the Management Board; [section 21] and

- represent the site community in any adjudicatory proceeding regarding site selection. [section 21]

The role of the Superior Site CSC in selecting the facility operator is extremely important. As part of that selection process, the CSC may negotiate with each operator applicant for any terms or conditions that the CSC deems to be necessary "to serve the site and neighboring communities' interests." Any agreements made by the applicant in order to secure selection as the facility operator will subsequently be incorporated into the comprehensive operating contract between the Management Board and the operator. Section 33(a) of Chapter 111H provides that the site, affected,[16] and neighboring communities are third party beneficiaries to the comprehensive operating contract. The CSC has the opportunity to consult with both the Board and the operator during such negotiations so that the comprehensive operating contract will include agreements to benefit the site, affected, and neighboring communities. Additional information about compensation and impact payments to the site, affected, and neighboring communities can be found in Chapter 16. A discussion of one particular form of compensation -- property value guarantees -- comprises Chapter 17 of this volume.

The Superior Site CSC may retain consultants from funds provided by the Management Board, and assist in the environmental review of the project. The CSC must also serve on a Citizens Advisory Committee appointed by the Secretary of the Executive Office of Environmental Affairs to establish a specific procedure for evaluating and reviewing the environmental impacts of facility development, operation, closure, post-closure, and institutional control. Public meetings on the draft Environmental Impact Report must be held in each site community and in neighboring communities, if requested by the CEOs.

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[15] The Management Board, however, certifies the potential facility operators who have met the Board's operator selection criteria regulations. Any potential operator who proposes more than one type of facility technology would receive a separate certification for each technology. This procedure will enable the Board to pre-screen proposed technology to ensure that the highest environmental protection standards will be met.

[16] An "affected community" is defined as a community, other than a site community, which is identified in an Environmental Impact Report (EIR) and can be expected to experience significant impacts as a result of the location, development, operation, closure, post-closure observation and maintenance, or institutional control of a facility.

Facility Operator. The company chosen by the site community CSC to develop and operate the facility is also subject to public participation provisions in Chapter 111H. Each applicant for operator certification is carefully reviewed by the Board as well as the Attorney General's office, on the company's record of compliance with environmental laws.

The Act also requires each applicant for facility operator (while under consideration or chosen as the superior site operator) annually to submit reports to the State Ethics Commission and the State Inspector General listing each expenditure made during the previous calendar year by various officials of the company which benefitted the Management Board, DPH, DEP, any CSC member, or the staffs of those entities. [section 22(b)] Such a requirement ensures the public that the facility operator will not be evaluated or chosen on the basis of "favoritism."

Each certified facility operator is required to participate in an advisory board to assist in the planning and implementation of detailed site characterization for all candidate sites. [section 22(d)]

Once selected, the facility operator must establish a field office within the site community in order to be accessible to community leaders and citizens. [section 28(b)]

Other statutory requirements to ensure public participation by the operator include:

- consulting with the CSC during the preparation of the Environmental Impact Report; [section 30(b)] and

- annually reimbursing the site community and DPH for the costs of its environmental monitoring program. [section 36(b)]

Department of Public Health. DPH requirements designed to ensure public participation during the various siting phases of Chapter 111H include:

- establishing a "decision schedule" for each complete facility license application that includes the dates by which it intends to issue a draft license or draft denial as well as to issue a final license decision; [section 31(a)]

- announcing to the site community, CSC, and other interested citizens, the commencement of the public comment period on a facility license application. [section 31(b)] The public comment period must continue for 45 days after DPH has issued a draft license or draft denial. During the comment period, anyone may submit comments in writing on the draft license or draft denial, and all written comments and memoranda prepared or received by DPH must be available to anyone requesting this information;

- conducting at least one public meeting on the license application and the draft license or draft denial within each site community, and other public meetings in neighboring communities upon the request of the local CEO; [section 31(b)]

- transmitting a copy of the draft license or draft denial to the CSC and others, which must be accompanied by an explanation of the reasons for issuance or denial, and a description of the procedures the DPH will follow to reach a final license decision; [section 31(c)]

- sending a copy of the final facility license decision to the CSC and others, accompanied by a summary response to all comments received during the public comment period and an explanation of any differences between the draft license or denial and the final license decision; [section 31(d)]

- establishing a "comprehensive environmental monitoring program" at the facility site. In doing so, DPH must consult with DEP and the local Board of Health. Chapter 111H also requires that this monitoring program provide, "to the maximum extent feasible, for the participation of officials and citizens of each site community and the training of such persons to facilitate their participation." The local Board of Health will be entitled to obtain portions of the samples collected under this monitoring program, designed to provide environmental data throughout the life of the facility, from the facility development stage through institutional control; [section 36(a)]

- issuing annually a report describing and evaluating the environmental monitoring program for public review and comment at a public meeting in each site community and in neighboring and affected communities (if their CEOs request such a meeting); [section 36(c)]

- periodically inspecting the facility during construction, in cooperation with officials of each site community; [section 37]

- holding public meetings on the facility operator's proposed facility closure plan for purposes of public review and comment; [section 43(a)] and

- issuing a report for public review and comment at public meetings, each year the facility remains in institutional control, regarding DPH's supervision of the Management Board's institutional control activities. [section 47]

Executive Office of Environmental Affairs. In order to further ensure public participation in the evaluation of environmental issues, Chapter 111H requires that an EIR "shall" be required, and that the project "shall" be considered "major and complicated"[17] within the standards identified in the Massachusetts Environmental Policy Act (MEPA) review procedure. [section 30(c) and (d)] The MEPA office of the Executive Office of Environmental Affairs (EOEA) is charged with reviewing the Environmental Impact Report.

In addition, Chapter 111H requires the EOEA Secretary to appoint a citizens advisory committee to assist in developing a scope of the EIR for preparation by the facility operator. The citizens advisory committee is to be composed of the Superior Site CSC members, and no more than six additional appointments by the EOEA Secretary.

Department of Environmental Protection. The role of the DEP during facility siting activities, which enhances the opportunity for public participation, is to ensure that its siting criteria and siting procedures regulations are properly followed by the Management Board. After the Board selects a superior site, if any aggrieved individual petitions DEP, the commissioner must commence an adjudicatory proceeding concerning site selection. Such a proceeding must be conducted following the requirements of Massachusetts General Laws c.30A, the State's Administrative Procedures Act. [section 24]

Chapter 111H requires that the Management Board, and representatives of the site and neighboring communities, shall be parties to any such adjudicatory proceeding. Any person aggrieved by the DEP commissioner's decision may seek judicial review in the Massachusetts Supreme Judicial Court.

Local Government. The role of municipal government officials in the facility siting process is

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[17] Neither great size nor complexity are necessary prerequisites to designation of a project as "major and complicated." Rather, state regulations [301 CMR 11.02] define such projects as those for which "a project-specific environmental review procedure" is appropriate. 301 CMR 11.12 observes that such a procedure can be useful, for example, in cases where several agencies or proponents have major roles in the project.

significant. The local activities described below and those under the heading for "The Public" are in addition to the local role already described for the CSCs. These activities Include:

- After the Management Board votes to initiate facility site selection, the Chief Executive Officer (CEO) of every community in the Commonwealth must receive:

  (a) notification of the commencement of the site selection process;

  (b) a detailed explanation of the site selection criteria, guidelines for their application and procedures for their implementation; and

  (c) an offer of resources to assist their participation in the site selection process.

- During site selection, once the Management Board issues a Report Identifying Possible Locations for siting, a notice must be sent to the CEO of each community that includes a possible location named in the report. That notice, at a minimum, must explain in detail:

  (a) all actions taken regarding the public meetings held to solicit public comments on all draft LLRW regulations and the draft Management Plan;

  (b) the procedures followed by the Management Board that led to facility siting; and

  (c) the actions taken by the Board with regard to siting.

- The Draft Candidate Sites Identification Report identifying candidate sites must be sent to each CEO of a municipality in which is located all or part of a candidate site named in the report. Before detailed site characterization is initiated, the CEOs of the communities where the candidate sites are located must establish local CSCs composed of:

  (a) the CEO or designee;

  (b) the chairperson of the local Conservation Commission or designee;

  (c) the chairperson of the Board of Health or designee; and

  (d) three residents of the community nominated by the CEO and approved by a majority vote of the City Council or Board of Selectmen.

- After a facility site is chosen, the site community's CEO must appoint two representatives of that community to serve on the Management Board.[18]

- If a petition is filed with the commissioner of DEP requesting an adjudicatory proceeding to challenge the conduct of the site selection process, the site and neighboring communities must be parties to the adjudicatory proceeding, and the communities' expenses will be reimbursed by the Management Board.

- After a facility license is issued, the site community's Board of Health must be consulted on the

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[18] If there is only one such site in the state, the site community CEO shall appoint one resident to the Board, and the CEO of the neighboring community, having the greatest population residing within three miles of the site, shall appoint the other Board member.

establishment of a comprehensive environmental monitoring program at the facility site. Such a program must provide for the training and participation of local officials and citizens of each site community. The local Board of Health is entitled to obtain portions of the samples collected under this environmental monitoring program for independent analysis.

- At the request of the site, neighboring, or affected community CEO, DPH must hold a public meeting in the community for public review and comment.

- During facility construction, local officials are authorized to inspect construction periodically, in cooperation with DPH.

- In addition to the public meetings already mentioned, other public meetings must be held for local officials and site and neighboring community citizens, at the request of the municipalities' CEOs. The occasions of such meetings include:

  (a) reopening a facility after temporary closure by DPH;

  (b) examination of the facility closure plan at least one year before the scheduled date of facility closure;

  (c) scrutiny of the draft institutional control plan developed by the Management Board;

  (d) comment on the annual report of the Management Board's institutional control of the facility; and

  (e) review of the annual DPH report evaluating the Management Board's performance during institutional control.

The Public. Citizens may exercise their rights in any phase of facility siting to request information, participate in public meetings, assist the CSCs, and review and comment on all siting documents.

In addition, Chapter 111H provides that any aggrieved person may appeal a siting decision via a request for an adjudicatory proceeding by the commissioner of DEP, and an appeal of that decision before the Supreme Judicial Court. [section 24]

Another law giving citizens authority over LLRW siting decisions is Massachusetts General Laws c. 164, Appendix, sections 3-1 to 3-9. This law, the Nuclear Power and Waste Disposal Voter Approval and Legislative Certification Act, was passed by referendum in 1982. It requires the Legislature to certify that a particular site is the "superior" site. Moreover, it requires that the Legislature's certification be confirmed by the voters on a statewide election ballot, for any storage, incineration (but not other treatment methods), or disposal facility sited in Massachusetts, unless such a facility is developed solely for the storage, incineration, or disposal of LLRW produced from medical or bio-research activities.

In 1986, the Massachusetts Supreme Judicial Court issued an opinion stating that the legislative certification and voter approval provisions of the referendum law could not be constitutionally incorporated into the regulatory structure established by Chapter 111H. The court gave this non-binding opinion at the request of the Massachusetts State Senate, not as a result of adversarial court proceedings. The action of the Legislature in enacting Chapter 111H, after this opinion was given, has raised questions about the applicability of the referendum law. If facility siting is initiated by the Management Board, it is expected that the legality of the referendum's legislative certification and voter approval provisions will be tested in court. The Management Board has been urged by some citizens to issue a legal opinion on the legislative certification and voter approval applicability issue. The Board has declined to do so, noting that the only

valid "opinion" would be the one from a court decision. The Board also declined to review this issue because it had not conducted a vote on long-range LLRW management decisions, including siting, and felt the timing of the question should await such decisions.

No Regulatory Waivers Permitted

Besides all the explicit public participation policies and procedures identified in the preceding paragraphs, Chapter 111H contains a very important requirement that further enhances the goal of public participation. The Act does **not** allow the Management Board or DEP to waive any of the site suitability criteria, adopted pursuant to section 14 of the Act.

Such a restriction against a waiver is unusual in state law. Waivers of environmental or health and safety regulations, which have occurred in Massachusetts and elsewhere, usually have reduced the credibility of the involved agencies, and have reduced the public's trust in the process. If facility siting is determined to be necessary, the Management Board does not want a similar situation to occur with its LLRW management activities.

However, it should be noted that Chapter 111H gives the Management Board authority to omit some of the site selection steps, including the selection of a facility operator by the CSC, which would eliminate some opportunities for public participation, if it votes to site a centralized interim or emergency storage facility. Before proceeding with this course of action, the Board would first have to revise the Management Plan and its Interim and Emergency Storage Plan.

5.4 Recommendations to Expand Opportunities for Public Participation

The provisions of Chapter 111H described in section 5.3 of this chapter are the statutory public participation requirements of the Act. They have been praised by Massachusetts officials knowledgeable about siting activities, as well as Bay State citizens who have experienced far less participatory siting processes.[19] In addition, they are considered a model of two-way public participation by other states whose citizen involvement requirements are deficient.

The requirements contained in Chapter 111H, particularly if siting is initiated and four state agencies become involved,[20] have also been described as difficult, complicated, and over-burdensome. There is no doubt that the Chapter 111H siting process is complex. The law was deliberately drafted in that fashion to ensure the maximum amount of public participation feasible, no opportunities for waivers of important siting criteria, and to explain with great specificity the roles and responsibilities of each involved and affected agency, community, homeowner, and citizen.

The viewpoints of citizens and government policymakers can vary dramatically, as is illustrated in

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[19] Testimony of state officials and citizens before the Legislature's Committee on Natural Resources and Agriculture, 1986, and personal interviews by the author.

[20] The Management Board, DPH, DEP, and the Executive Office of Environmental Affairs are the main state entities involved in the Chapter 111H siting process. Other state entities play diminished roles, such as the Division of Capital Planning and Operations.

Table 5-4. That is why it is so important to develop and retain two-way communications. As Table 5-4 shows, issues relating to LLRW management that have the greatest importance to the public may not be the concerns of policymakers charged with managing LLRW on behalf of the Commonwealth.

Table 5-4
Environmental Concerns of the Public as Compared to Environmental and Health Priorities of the U.S. EPA

EPA's Greatest Concerns	The Public's Greatest Concerns[a]
Health Risks:	(1) Active hazardous waste sites (67)
• Criteria air pollutants (e.g., smog)	(2) Abandoned hazardous waste sites (65)
• Toxic air pollutants (e.g., benzene)	(3) Water pollution from industry wastes (63)
• Radon	(4) Occupational chemical exposure[b] (63)
• Indoor air pollution	(5) Oil spills (60)
• Drinking water contamination	(6) Ozone depletion[b] (60)
• Occupational chemical exposure	(7) Nuclear power plant accidents (60)
• Pesticide application	(8) Pollutants from industrial accidents (58)
• Stratospheric ozone depleting	(9) Radiation from radioactive wastes (58)
	(10) Air pollution from factories[b] (56)
Environmental Risks:	(11) Leaking underground storage tanks (55)
• Global climate change	(12) Pollution of coastal waters (54)
• Stratospheric ozone depletion	(13) Solid waste (53)
• Alteration of habitats	(14) Pesticide application[b] (52)
• Species extinction	(15) Water pollution from agricultural run-off (51)
• Loss of species diversity	(16) Water pollution from sewage treatment plants (50)
	(17) Vehicular air pollution[b] (50)
	(18) Pesticide residues in foods (49)
	(19) Greenhouse effect[b] (48)
	(20) Drinking water contamination[b] (46)
	(21) Wetlands destruction (42)
	(22) Acid rain (40)
	(23) Water pollution from city run-off (35)
	(24) Solid waste sites (31)
	(25) Biotechnology (30)
	(26) Indoor air pollution[b] (22)
	(27) Radiation from x-rays (21)
	(28) Radon[b] (17)
	(29) Radiation from microwave ovens (13)

[a] Figures in parentheses represent the percentages of persons surveyed who ranked the problem as "very serious."
[b] Also one of EPA's highest concerns.

Source: U.S. Environmental Protection Agency. Reducing Risk: Setting Priorities and Strategies for Environmental Protection. Washington, DC, September, 1990.

In addition to the statutorily-mandated provisions for public participation contained within Chapter 111H, the following are also recommended:

Open, honest communications. All agencies of the Commonwealth responsible for various aspects of LLRW management should communicate to the public with honesty, consistency, competency and fairness. The importance of public participation cannot be overstated. As government grapples with environmental and public health problems, and seeks solutions that may increase the controversial nature of the problems, government and citizens must understand each other. Government agencies must listen to the public -- both lay individuals and those with scientific or technical training -- in order to appreciate the social values and technical concerns that are important to them. In addition, the public must listen to government scientists and policy analysts, in order to understand -- not necessarily accept -- their point of view.

Availability of studies and documents. No studies or other documents that are public records under the state law should be kept confidential relevant to the implementation of the Management Plan. "Public records" are defined in the State's Public Records Law, Massachusetts General Laws c.4, section 7, clause twenty-sixth, as "all books, papers, maps, photographs, recorded tapes, financial statements, statistical tabulations, or other documentary materials or data, regardless of physical form or characteristics, made or received by any officer or employee of any agency, executive office, department, board, commission, bureau, division or authority of the Commonwealth, or of any political subdivision thereof, or of any authority established by the [Legislature] to serve a public purpose..." unless such materials or data fall within 13 exemptions. The exemptions that would apply to activities of the Management Board, the CSCs, and other entities involved in LLRW management include records solely related to internal personnel rules and practices; personnel and medical files; inter-agency or intra-agency memoranda; personal employee notes; investigatory materials compiled by law enforcement officials; trade secrets or commercial or financial information voluntarily provided to an agency for use in developing governmental policy, and contract proposals and bids until they are publicly opened.

It is the recommendation of the Management Board that all documents that fall under the "public records" provisions of state law be made available to interested persons. The actions of the Management Board and other entities involved in LLRW management should continue to be publicly scrutinized, especially if a decision is made to proceed with facility siting.

Public Participation Plan. The Management Board will develop a Public Participation Plan that identifies citizen involvement policies and procedures beyond the mandates of Chapter 111H. Such a plan[21] will include, but not be limited to, a statement of goals, and procedures to accomplish the goals.

Chapter 111H has been recognized by legislative experts, both in Massachusetts and elsewhere in the country, as a law that contains extraordinary detail on the policies and procedures of implementing two-way public participation. While the Management Board agrees with this description, it also feels some additional provisions for public participation are valuable to the management of LLRW. Some of the elements of the Board's Public Participation Plan, which exceed the mandates of Chapter 111H, appear, on the surface, to be modest. However, taken together, they reflect the Board's commitment to ensure genuine two-way communications.

Some of the Public Participation Plan policies that surpass the requirements of Chapter 111H, include:

- the Board's commitment to hold more than the required number of public meetings (i.e., the

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[21] A Public Participation Plan is contained in Appendix 5A of this chapter.

"two-way communication" style of "public hearings") stipulated in the Act; to hold small-group "briefing sessions" that allow informal discussions and exchanges of information; and to hold Board meetings throughout the state, when possible, as additional ways of encouraging interested citizens and organizations to involve themselves in the Board's activities;

- taking more than the required statutory steps to provide public notice of Board meetings and pending actions, for example by placing paid advertisements in newspapers and other media outlets, rather than depending on news columns and news broadcasts; and making certain that members of professional societies with knowledge in radiation-related fields serve with the public as a "sounding board" in the development of Board policies; and

- prior to a vote on siting, notifying not only the CEO of each community, as required by Chapter 111H, but also the chief elected official of every municipality of the date, time, and place of such a vote.

- If siting is initiated, conducting public meetings at stages in the site selection process that are not required by Chapter 111H, such as after the issuance of the Statewide Mapping and Screening Report;

- If an affirmative vote to site an in-state facility is made, developing a "siting plan" identifying the major decision points in the State's siting process, and summarizing the roles of responsible state agencies and potential site communities; and

- If facility siting is begun, taking extra steps to ensure the participation of local officials, citizens, and organizations in the areas where candidate sites and a superior site are identified.

One of the general recommendations of the Public Participation Plan warrants additional emphasis. That is, if a decision is made to initiate in-state facility siting, the Management Board will ensure that efforts are made to involve the officials, citizens, and organizations of local municipalities that may not be identified as "site," "neighboring," or "affected" communities according to the provisions of Chapter 111H.

The issue of formal participation in the siting process was the subject of considerable Management Board discussion and debate in the review of this Management Plan, following receipt of public comments. Because it was not the entity that drafted Chapter 111H, the Board sought to understand the reasoning behind the designation of the three major categories of local communities for which Chapter 111H concentrates the authority of local siting review. Discussion included the idea of providing formal participation for every municipality that abuts a site community. The Board also considered suggestions that an arbitrary distance from a candidate site should be identified for purposes of formal interaction between local governments and local citizens, with the Management Board.

The Board ultimately agreed with the drafters of Chapter 111H, whose decision to identify "site," "neighboring," and "affected" communities resulted from meetings with local officials and citizens that had taken part in initial siting activities under the state's hazardous waste siting law, Massachusetts General Laws c.21D. During those meetings, there was a recognition that every "abutting" community is not necessarily impacted in the same manner, or to an equal extent. (For example, one abutting community may be close to a potential site; another abutting community may be miles away, and have little or no population within the vicinity of the candidate site community.) From their discussions, the Management Board came to appreciate the unique provisions of Chapter 111H, that are geared to ensure that those communities **most** impacted would have responsibilities under the law, and would receive compensation.

As a result, the Management Board has expressed the importance of having it, and its staff, work to involve local officials, citizens, and organizations in communities that are not identified as "site,"

"neighboring," or "affected" under the statute. The Board will strive to encourage attendance at CSC meetings, Board meetings, potential operator advisory committee meetings,[22] and other meetings involving the site selection process.

Encourage volunteer sites. If a decision is reached to initiate the Chapter 111H siting process to identify lands within the Commonwealth for an LLRW storage, treatment, or disposal facility, the Management Board should seek communities and others interested in volunteering land as a site for such a facility. All communities and others interested in the potential of volunteering sites should receive funds from the Management Board to evaluate the economic impacts of a facility.

As part of the notification to municipal officials and others that a decision to site an in-state disposal facility has been made, the Management Board will inform local community and regional leaders of its "volunteer" provisions in the siting process, and will encourage participation.

The Board will then undertake a series of public meetings over the span of perhaps six months, to develop the details of its volunteer program. After it has completed its first statewide site screening activity to eliminate what appears to be unsuitable areas of the Commonwealth, and has issued its Statewide Mapping and Screening Report, the Board will send a second notice to all municipalities contained within the "possible locations" about the volunteer program. Officials and others in those communities will be encouraged to evaluate the economic impacts of LLRW disposal, and to volunteer possible sites for consideration. Those communities will be eligible for grants from the Management Board to evaluate the economic impacts of having an LLRW disposal facility within their borders.

In their communications regarding the volunteer site provision, the Board will make explicit that no such volunteered sites will remain in the site identification process if they fail to meet the environmental screening criteria of the DEP siting regulations.

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Appendix 5A: Public Participation Plan

5A.1 Purpose of Plan

This plan establishes a framework for effective public participation in the decisions of the Management Board. It has been built upon the premise that people have a right to be involved, and should be involved, in decisions that could affect them. It outlines a program of two-way communication opportunities to inform, educate, and solicit participation from citizens of the Commonwealth. It is meant to be dynamic, evolutionary, and open to modification based upon citizen advice and changing needs.

Some of the activities described here are to be implemented <u>only</u> if the Management Board determines that a low-level radioactive waste (LLRW) storage, treatment, or disposal facility is necessary to be sited, built, and operated in Massachusetts. The rest of the activities are meant to be fulfilled to the extent that financial support is available for them.

Some of the activities outlined here are mandated by law. However, as evidenced by this plan, the Management Board supports public participation beyond the mandates of the law. For example, Massachusetts General Laws c.111H (Chapter 111H), the State's Low-Level Radioactive Waste Management Act, requires that six consolidated public meetings be held prior to the adoption of LLRW regulations and the LLRW Management Plan. This public participation plan adds a series of small group briefings and other meetings to be held before the consolidated public meetings take place.

The Management Board strongly believes that the public's view should be sought before important decisions are made. Decisions can be made both technically improved and socially more workable when a public participation program is properly effectuated. This policy underlies the following public participation plan goals.

5A.2 Public Participation Plan Goals

- To establish an interactive process of citizen involvement in the Management Board's decision-making which is based upon continual and open two-way communications, education, and bona fide efforts to address collective concerns.

- To enable the citizens of the Commonwealth to assist the Management Board in reaching well-informed, technically sound, publicly responsive decisions that can be successfully implemented.

- To provide relevant information to the public. Information about LLRW management is essential to an understanding of the issues involved. This understanding can help the public make balanced assessments of the issues, and provide informed opinions.

5A.3 Mechanisms and Procedures to Accomplish Goals

The plan outlined below is intended to realize the goals noted above and is divided into three principal activities as follows:

(1) Establishing a communications infrastructure;

(2) Developing information materials and an education program; and

(3) Instituting a community and citizen outreach program.

The activities detailed in this plan are not without limitations. Although a comprehensive public participation program is outlined, it is not the intent of this plan to implement each activity statewide and simultaneously. Rather, appropriate elements will be implemented as conditions warrant and financial constraints allow.

(1) Establishing a Communications Infrastructure

The Management Board views establishing and maintaining effective two-way communications as the cornerstone of public participation. This section sets forth the basic components of a communications infrastructure designed to verify that the public's concerns are being identified and evaluated.

Communications Network: To establish and maintain quick, easy, and clear lines of two-way communications between communities, citizens, organizations, others, and the Management Board.

Potential Implementation Mechanisms:

- Create telecommunications tree; for information exchange notifications
- Network with organizations interested in LLRW issues

Public Concern Tracking System: To develop a system that tracks the content and source of public concern and documents how this concern is addressed.

Potential Implementation Mechanisms:

- Management Board minutes
- Periodic reports
- Correspondence
- Computerized data-base

Media Relations: To promote accurate and complete media coverage of LLRW issues by providing a forum for the informal exchange of information.

Potential Implementation Mechanisms:

- Media workshops

- Ongoing preparation of issues-oriented and background press releases on major issues

- Meetings with editorial boards to discuss critical issues; follow-up with reporters covering issues

- Press interviews on request

- Tape and distribute process and issue-oriented public service announcements

- Newspaper Inserts in potential site communities (if siting goes forth)

Coordination With Other Involved Agencies: To coordinate the public participation efforts of the Management Board, the Massachusetts Department of Environmental Protection (DEP) and the Massachusetts Department of Public Health (DPH), who share a responsibility to inform and involve the public in their parts of the overall LLRW management process. Coordinating these efforts is vital to the successful Implementation of a public participation program.

Potential Implementation Mechanisms:

- To achieve a coordinated public participation program, a working group of appropriate staff from DPH and DEP will meet as necessary with the Management Board's Public Participation Coordinator in order to discuss public participation activities, to coordinate information and activities, and to discuss the public issues common to all of the agencies' programs and activities. The Public Participation Coordinator will make recommendations and assist each agency in the development of plans for public participation (noted in M.G.L. c.111H 6(b)). Where appropriate, public participation activities will be jointly sponsored, and representatives of all Involved agencies will attend and participate in related events. DPH and DEP will agree on protocols necessary to allow the Public Participation Coordinator to serve as lead LLRW public participation facilitator for all agencies.

Mailing List: To establish a mailing list for the receipt of Management Board correspondence, information and announcements. At a minimum, the mailing list will include the names, addresses, and telephone numbers of the following:

- Citizens expressing interest or requesting regular mailings

- All municipal chief executive officers

- All boards of selectmen/aldermen, and city councils

- All municipal boards of health

- All municipal fire chiefs

- All municipal planning boards

- All municipal planning departments

- All municipal conservation commissions

- All regional planning agencies

- All municipal hazardous waste coordinators

- University environmental, engineering, and physics faculty and student groups
- High school science department heads and science teachers
- All members, Massachusetts Congressional delegation
- Governor and Lt. Governor's key policy heads (i.e., Governor and Lt. Governor's key central office staff and Cabinet secretaries of Environmental Affairs, Health and Human Services, Economic Affairs, etc.)
- All members, Massachusetts Legislature
- Heads of statewide municipal, environmental, and health organizations
- Heads of statewide organizations representing radioactive materials users
- Heads of all Chambers of Commerce
- CEOs and radiation safety officers of all licensed radioactive materials users in the Commonwealth
- Heads of hospital auxiliary associations
- Members of professional societies involved in issues relating to LLRW management
- State and local League of Women Voters officers
- Television and radio stations
- Local cable TV stations

Quarterly Newsletters: To produce a quarterly newsletter with information on the current status of issues that are important to LLRW management. This newsletter will be free and widely distributed.

(2) Education and Information

The Management Board views education and information as critical components of public participation. Information about LLRW management and the siting process (if applicable) is essential to understanding technical concerns and other issues involved. Armed with clear and objective information regarding LLRW management issues and the public participation process, citizens will be able to formulate independent opinions and have their concerns effectively addressed. The activities outlined below are designed to provide this information.

Public Information Materials: To provide a variety of public information materials that support the Management Board's public information and outreach activities.

Potential Implementation Mechanisms

- Develop informational packets, guidance documents, and fact sheets for distribution to citizens, media, local officials, health, environmental, and related organizations. Typical documents to be produced may include:

- Fact sheets on LLRW issues and siting process (if applicable)
- Ionizing radiation facts
- Management Board responsibilities
- Benefits to society of the products and services that generate LLRW
- Control, minimization, and elimination, where feasible, of the use of radioactive materials that generate LLRW
- Federal mandates
- Role of public in citizen participation
- How the management of LLRW affects the public, the environment, and the economy
- Safe technologies for LLRW disposal
- Summary of Chapter 111H
- Public Participation Plan
- Management Board newsletter
- Explanation of regulations
- Site selection process (if applicable)
- Synopses of various processes and how to get involved
- Interaction of federal, state, and local laws in regards to LLRW
- Siting Plan (if applicable), identifying the major decision points in the state's siting process, and summarizing the roles of responsible state agencies and potential site communities.

Low-Level Radioactive Waste Information Resource Center: To establish and maintain a library of documents pertaining to LLRW management in Massachusetts and other states at the office of the Management Board. These documents will be available for public use. Copies will be made available, or loaned, to interested citizens upon request and availability.

Potential Implementation Mechanism:

- Coordinate information dissemination with DEP who, pursuant to section 14 of Chapter 111H, is required to establish a statewide resource center for the continual collection of data pertaining to site selection (if applicable).

Radioactive Material Users and LLRW Generators Round-Table: To augment on-going meetings with radioactive materials users and LLRW generators for the purpose of exchanging information about LLRW management issues, and identifying impacts (positive, negative, health, safety, economic, etc.).

Potential Implementation Mechanisms:

- Semi-annual meetings of the Management Board and radioactive materials licensees

- Issue-oriented round-table sessions with representatives of LLRW generators and state agency officials

School System Program: To assist in educating secondary school students on the fundamentals of radiation, radioactive waste management issues, and related topics.

Potential Implementation Mechanisms:

- Lectures, demonstrations, video presentations

- Develop curriculum units or teachers workshops, or establish a program to loan educational materials developed by others (e.g., U.S. Department of Energy, radiation protection societies, etc.) which are available through an LLRW Information Resource Center

Facility Site Visits (only if siting process is initiated): To assist interested persons in gaining a better understanding of LLRW management, through visits to existing LLRW sites in other states.

(3) Outreach Activities

Creating opportunities to explain regulations and processes, answer questions, and seek public input from people who live and work, or have a vested interest in Massachusetts, is a priority of the Management Board. These opportunities will be encouraged by implementing the activities noted below.

Management Board Meetings: To help ensure citizen participation in Management Board activities, regardless of their geographic location, by conducting some of the regular business meetings of the Management Board at various locations around the state.

Potential Implementation Mechanisms:

- Place notices in local papers (both news releases and paid advertisements, where appropriate)

- Use mailing list to notify citizens and groups in area

- Retain transcripts as minutes of Management Board meetings

Public Meetings: To conduct statutorily-mandated public meetings to explain items proposed, answer questions, and to solicit public opinion.

Potential Implementation Mechanism:

- The Management Board will hold public meetings on all major decisions, regulations, plans, and reports in order to receive comments from as broad a spectrum of the public as possible. These public meetings are more expansive than public hearings because they allow a dialogue to occur. Public meetings defined in Chapter 111H require an agency to present information, hear testimony, and respond to inquiries. In contrast, public hearings only allow testimony to be received. The Management Board will widely advertise and publicize its public meetings, circulate information on the topics to be considered and discussed, and use the public meetings as forums for listening and responding to the public.

Public Participation Advisory Committee (per Chapter 111H, section 6(d)): To create a committee

of persons representing the range of public opinion concerning LLRW management that will advise and assist the Public Participation Coordinator in establishing and conducting public information programs, as well as developing procedures to be used to achieve a fair and effective process of public participation.

Briefings and Other Meetings: To conduct small group briefings and meetings to more fully explain items to be discussed at the statutorily-mandated public meetings.

Potential Implementation Mechanism:

- Prior to conducting public meetings, and as an integral component of the public review process, briefings and meetings will be held to describe the purpose and content of the material to be considered at the hearings. The Management Board recognizes that formal public meetings may not give all citizens the opportunity to understand the content of the materials fully. Therefore, briefing sessions and question-and-answer meetings will be held as necessary, prior to, and following, statutorily-required public meetings at various locations around the state, as time permits. Communities will also be asked what types of forums they prefer, and be encouraged to work with the PPC to develop a process of participation with which they are comfortable. Subsequent meetings will explain how previous community input was addressed.

Ad Hoc Panels: To create ad hoc panels of technical experts, municipal officials, citizens, and others, as necessary, to focus on specialized issues.

Small Group Presentations: To conduct ongoing informal presentations and consultations with municipal decision-makers, environmental groups, health organizations, government leaders, civic groups, Chambers of Commerce, and others to provide information about Management Board activities, and to solicit public opinion regarding these activities.

Potential Implementation Mechanisms:

- Conduct small group meetings and presentations in selected areas of the state

- If siting proceeds, these meetings will be held frequently in the areas of possible locations which are likely to contain one or more candidate sites, and in areas of candidate sites.

- If siting proceeds, these meetings will be available to Community Supervisory Committees to assist them in the evaluation of alternative facility technologies.

Briefings for legislators, state agencies, local officials, others: To maintain continued information and involvement opportunities for state legislators, state agencies, local officials, and others on all aspects of Management Board activities.

Potential Implementation Mechanisms:

- Send informational materials and key program documents to members of the state Legislature, state agencies, local officials, and others.

- Sponsor information briefings for legislators, local officials, and others interested in LLRW management.

Speakers Bureau: To provide speakers on LLRW management issues to groups who request them.

Potential Implementation Mechanism:

- Speakers to be drawn from Management Board members, staff, university faculty, physicians, health physicists, and others willing to give presentations about LLRW management or issues.

Workshops: To organize workshops on LLRW issues of interest to local citizens, in order to provide opportunities for two-way dialogue between state policymakers and citizens.

Topics may include:

- Basic radiation facts
- Public health, safety, and uses of radioactive materials in Massachusetts
- Environmental protection
- Source and waste volume minimization
- Storage, treatment, and disposal technology
- The siting process (if applicable)

Community Supervisory Committees (CSCs) (per Chapter 111H, section 21, only if siting process initiated): To facilitate and maximize participation of CSCs in Management Board activities. Chapter 111H recognizes the importance of local involvement in any decision that could affect a community. Thus, it established a mechanism for a site community to assess the local impact of site development, and to communicate its view to the appropriate parties.

Potential Implementation Mechanisms:

- Assist communities in establishing CSCs
- Assist communities to understand operating ground-rules established by Management Board
- Outline technical assistance to be provided by Management Board
- Assist members to understand their responsibilities, the steps in the process, schedule, and when and how the Management Board will incorporate CSC input into its decisions.

Local Information Offices (only if siting process initiated): To establish an office to assist residents in candidate sites to follow the range of activities that will occur during site characterization, and to understand how further decisions will be made.

Potential Implementation Mechanisms:

- Work with and through municipal officials to locate space
- Initiate opening immediately following selection of the candidate sites
- Staff by public participation specialist
- Information displays
- Strive to have space used as community resource

General Public Notification Process: The Management Board will hold briefings and public meetings on all major regulations, plans, decisions, and reports as outlined above. The overall process regarding the announcement of these events is described below. In addition, the Management Board will be guided by a policy to notify communities and their leaders as soon as possible about decisions that may affect them.

Preceding Announcement:

1. The Management Board will send notifications to all persons and groups on its mailing list in the area of the public meeting. Notification will contain dates, times, locations of public meetings, and will be distributed to allow sufficient time for citizens to make arrangements to attend.

2. The Management Board will send press releases to pertinent newspapers, radio stations, and television stations. Releases will include notice of press conference and availability of press conference packets.

3. For statutorily-mandated public meetings, the Management Board will publish notices in selected newspapers and other publications at least 21 days prior to the public meeting, in accordance with Massachusetts General Laws c. 30A.

Day of Announcement:

1. When appropriate, a press conference will be held announcing decision, document, or report, and dates of public meetings to explain them and to receive comments. As applicable, the Management Board, DPH, and DEP will conduct presentations to explain implications of the decision, document, or report.

2. An informational packet will be mailed to all press (newspapers, radio, TV, cable) in vicinity of public meetings with press release announcing meeting schedule.

Before Public Meetings Begin:

1. A press release will be sent to local media in vicinity of public meetings and selected major media. The public's role in LLRW management will be explained.

2. Follow-up calls will be made to local officials, local organizations, and local media in vicinity of public meetings, requesting their attendance and participation.

3. Materials available at the meetings will include:

   - Informational packets
   - Public Comment Forms
   - Extra press releases
   - Copies of the material or decisions to be reviewed

Following Public Meetings:

1. The Public Participation Coordinator will organize public comments for Management Board review.

2. The Management Board will inform, personally and by letter, all impacted CEOs concerning its major decisions, reports, or documents, and offer the services of the Management Board and the Public Participation Coordinator. Meetings will be held to discuss each major decision, report, or document, and to solicit input from CEOs.

3. The Management Board will issue press releases explaining the significance of major decisions, reports, or documents to newspapers, TV, radio stations, and selected media as appropriate.

4. When appropriate, the Public Participation Coordinator will issue a brief report relative to its major decisions, reports, or documents, explaining how public input was utilized to persons that offered input.

5. (Only if siting process initiated): Copies of the decision or document will be sent to all impacted municipal CEOs and all municipal libraries of impacted communities.

6. (Only if siting process initiated): The Management Board will conduct workshops or small group meetings, prior to the next step, to:

   - provide information
   - answer additional questions
   - listen and learn concerns from the public

Chapter 6: Regional Compacting and Negotiations With Other States on LLRW Management

6.1 Introduction

Regional low-level radioactive waste (LLRW) facility agreements are executed between states through regional compacts[1] or contracts. Besides the Governor's office, two state agencies are responsible for negotiating agreements with other states for LLRW management. One is the Massachusetts Low-Level Radioactive Waste Management Board, which is directed to represent the Commonwealth in all regional negotiations for the purpose of establishing a regional LLRW disposal facility. [St. 1987, c.549, section 6] The other state entity is the Executive Office of Environmental Affairs, whose Cabinet Secretary -- also a member of the Management Board -- has been directed by the Governor to perform an LLRW negotiating function. The Secretary's office and the Management Board office are working together cooperatively to pursue regional LLRW management solutions.

The law authorizing the Management Board to negotiate regional LLRW facility solutions also requires that this Management Plan contain a detailed report of:

- all negotiations conducted prior to the Board's establishment, and
- a study of the feasibility of Massachusetts entering into a regional compact, that identifies appropriate compacting states.

This chapter addresses these subjects, which represent a separate but parallel activity to options involving in-state facility siting.

6.2 Negotiations Conducted Prior to the Establishment of the Management Board

This section describes all negotiations conducted prior to July, 1988, the date the Management Board was "established" by gubernatorial appointment.

<u>CONEG Policy Working Group</u>

In December, 1980, Congress passed the Low-Level Radioactive Waste Policy Act (LLRWPA), which

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[1] A regional "compact" is a legislatively-authorized contract between states. States frequently join compacts when a solution to a particular problem can best be provided on a regional or interstate basis. Each compact provides assurances of long-term commitments and continuing cooperation among states. Compact agreements must be ratified by each state's legislature and then by Congress.

assigned to each of the 50 states the responsibility for LLRW management and disposal, and encouraged states to form regional compacts and to develop regional disposal sites. To motivate states to regionalize, the Policy Act provided that states establishing compacts may deny generators in non-member states access to the disposal facilities in the compact regions.

A few months later, in August, 1981, an organization of governors called the Coalition of Northeastern Governors (CONEG) agreed to form a working group to organize one or more interstate LLRW compacts for consideration by the legislatures of the participating states.

The CONEG "Policy Working Group" (PWG) was organized in September, 1981, and represented officials from the executive and legislative branches of each state, credentialed by their governors to negotiate a regional compact agreement. The PWG and its advisory "Technical Subcommittee" initially represented the states of Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont. Several months after meetings began, the states of Delaware and Maryland petitioned to join, and were added to the group.

The PWG met for 18 months and developed a draft regional compact. According to a report issued by the group:

> "It consciously chose not to anticipate and resolve every problem which might emerge, nor to specify in detail how each responsibility under the Compact must be performed. As a single document which balances the interests of the sovereign states, the federal government and the region in LLRW management, the draft Compact is designed as a basic charter of interstate and state-federal relations. It sets forth the principal rights and responsibilities of the signatory parties and provides guidance for future individual and collective decisions of the states."[2]

The PWG submitted its recommendations to the 11 governors in February, 1983. The four major provisions of the CONEG Compact included:

(1) a description of the major duties and responsibilities of the member states, the host states that would site facilities, and the regional compact commission;

(2) creation of a regional commission, called the Northeast Interstate Low-Level Radioactive Waste Commission, to serve as a coordinating group to administer the Compact and to ensure that the collective interests of the party states were considered in LLRW management decisions;

(3) a process for selecting a host state; and

(4) sanctions and penalties for party and host states that failed to meet their legal commitments, and terms and conditions under which a state may join the Compact or rescind its membership.

The specific provisions of the Compact and a narrative explanation of each are contained in a report issued by the PWG in March, 1983. Excerpts from this report are contained in Appendix 6A.

The Massachusetts PWG representatives had some reservations about certain aspects of the draft Compact that had not been resolved before the submission of the document to the 11 governors. These

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[2] CONEG Low-Level Radioactive Waste Policy Working Group. Low-Level Radioactive Waste in the Northeast; Report to the States. CONEG Policy Research Center, Inc., Washington, DC, March, 1983.

concerns were communicated to Governor Michael Dukakis. However, the Governor submitted the CONEG compact to the Massachusetts Legislature [H.6451] on June 6, 1983, to indicate to the other 10 PWG states that Massachusetts was still interested in regional compacting. At the same time, Governor Dukakis announced his Administration's intention to negotiate some language changes with the other 10 states involved in the CONEG process, and asked the Massachusetts Special Commission on Low-Level Radioactive Waste to recommend the necessary amendments.

Five public hearings were held statewide by the Special Commission, a group of state legislators, state and municipal government policymakers, environmentalists, and representatives of radioactive materials users, established in 1981 to assess and evaluate the LLRW management situation in Massachusetts, and to make recommendations to the Governor and the Legislature, including guidance on compacting.

The Special Commission's hearings pinpointed specific concerns of Massachusetts citizens regarding the proposed CONEG Compact. Areas of strongest concern included the rights and obligations of the host state, the authority of the Compact Commission, the process for selecting host states, liability, repeal of inconsistent state laws, and the size of the Compact region.

New Compact Version

On September 26, 1983, the Special Commission announced its view that the proposed CONEG Compact, unamended, was inappropriate for Massachusetts, but recommended that the state work to modify the CONEG language and explore regional options other than the 11-state compact. The CONEG Compact legislation subsequently died that year in the Massachusetts Legislature.

Meanwhile, discussions continued with the other 10 states in the CONEG group, as Massachusetts officials hoped some or all of these states would agree to the language amendments under review by the Special Commission. Those amendments were incorporated into compact language redrafted by the Special Commission, and covered the following key issues:[3]

Rights and obligations of the Host State. It was felt that the CONEG draft compact failed to provide a host state with adequate protection and authority over the operation of a regional disposal facility. Consequently, the Special Commission compact transferred that authority to the host state. In addition to the host state's right to have two members on the Compact Commission as proposed in the CONEG compact, the Special Commission compact gave the host state veto power on important decisions affecting it. These included the export and import of wastes to and from other regions, and action on a state's application to join the compact. The Special Commission compact also proposed to retain the two host-state votes on the regional commission for decisions affecting its facility during the facility's institutional control period, as well as the operational phase.

Regional Commission Authority. The CONEG compact gave the regional commission broad authority in determining its procedures for rule-making, public participation, judicial review, host-state selection, and imposition of sanctions. The Special Commission compact transferred some of these powers to the host state, and limited others.

Repeal of inconsistent state laws. During the 18 months of discussion that resulted in the CONEG compact draft, a statewide referendum was adopted in Massachusetts requiring the state Legislature to certify, and the public to endorse through a statewide ballot vote, the selection of an LLRW disposal site. [M.G.L. c. 164, Appendix 3-1 to 3-9] Similar referenda questions were also being promoted in other states

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[3] This summary of principal concerns with the CONEG compact is reproduced substantially as written from a February, 1985, report of the Special Commission entitled Moving toward a Solution.

within the CONEG region.

Because of concerns of some PWG members that this new Massachusetts referendum law would prevent the Commonwealth from ever being able to site an LLRW disposal facility within its borders, the CONEG compact included a provision stating, "All laws and regulations, or parts thereof of any party state or subdivision or instrumentality thereof which are inconsistent with this compact are hereby repealed and declared null and void." Massachusetts PWG members asserted that the referendum provided a siting **process**, not a siting **prohibition**. They also argued that the Administration and the Special Commission were committed to improve upon the process established in the referendum. The "inconsistent state laws" language contained in the CONEG document was removed in the Special Commission's compact recommendations.[4]

Host State Selection. The CONEG compact proposed that the Compact Commission select the host state based upon six criteria:

(1) the health, safety, and welfare of citizens of the party states as defined by the appropriate regulatory authorities;

(2) the environmental, economic, and social effects of a regional facility on the party states;

(3) economic benefits and costs;

(4) the volumes and types of waste generated within each party state;

(5) the minimization of waste transportation; and

(6) the existence of regional facilities within the party states. [CONEG Compact, Article V(c)1]

Massachusetts PWG representatives and citizens who commented during public hearings expressed a major concern that the Compact Commission in the CONEG proposal could force a facility upon an unwilling host-state, and that environmental, health and safety considerations were not clearly stated as the first and major priority in host state selection. Rather, the criteria listed above suggest that states that are centrally located, and generate larger volumes of LLRW, have the greatest likelihood of being selected as host states. The states that best fit those criteria were Massachusetts, New York, and Pennsylvania.

Given the inequitable site selection criteria included in the CONEG draft, the provision granting each state an equal vote on all compact matters, whether or not they ever would be designated as a host state, made this part of the CONEG compact extremely untenable for Massachusetts.

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[4] Legislation filed to provide for the management of LLRW in Massachusetts (which became Massachusetts General Laws c.111H (Chapter 111H), included specific instructions to carry out the requirements of the referendum's certification and ballot vote requirements. However, that section was not included in the final version of Chapter 111H signed into law in 1987. In 1986, the Massachusetts Supreme Judicial Court offered an opinion on the constitutionality of the referendum in answer to questions requested by the State Senate. The Court said that (1) the legislative certification requirement of the referendum which would allow one branch of the Legislature to block construction and operation of an LLRW facility "already found by the executive branch to warrant licensure encroached impermissibly on the power of the executive in violation of the separation of powers" principles of the state Constitution; and (2) the voter approval provision did not conform to the initiative and referendum procedure, and was not constitutionally permissible. The action by the Legislature in enacting Chapter 111H after the Court's opinion raises questions about the continued applicability of Chapter 503.

The Special Commission's compact draft did not propose one solution to this problem. Rather, it offered several options for a host state selection process, and urged further reaction and public comment before a final host state selection policy was established.

Liability. The CONEG compact assigned the responsibility of liability for third party injury or damages to the facility operator and the host state, and excluded other party states from third party liability. Massachusetts expressed concern with the inequity of that proposal. The Special Commission compact provided stronger assurances for third party compensation, and modified the amount of Compact Commission discretion over the institutional control fund.

A preliminary draft of the Special Commission compact was presented to officials of the other northeastern states at a compacting meeting in Boston in April, 1984. The other states in attendance updated their status regarding the 11-state CONEG compact and other LLRW-related activities, as follows:

Delaware: did not want to re-negotiate another compact, but was not opposed to amendments to the CONEG document.[5]

Maine: No action had occurred on the CONEG proposal because Maine's LLRW Siting Commission had recommended that the state not join the 11-state region, but consider instead a compact with New Hampshire, Maine, and Vermont.

New Hampshire: The CONEG draft died in the Legislature's 1983 session. A redrafted version was to be introduced in 1984.

New Jersey: Amendments similar to those proposed by the Massachusetts Special Commission had been introduced into the New Jersey Legislature. New Jersey would not negotiate a new compact until another state signed new language into law.

New York: The CONEG draft was undergoing legislative review, but was not expected to be acted upon until recommendations were made by the New York State Energy Office and its Citizen's Advisory Committee. The Committee was expected to recommend rejection of the CONEG version in favor of negotiating with a smaller number of states.

Rhode Island: The CONEG compact was approved in 1983 in the Rhode Island House of Representatives, but died in the Senate. The measure would be re-introduced and the Massachusetts amendments would be considered.[6]

Vermont: Both the CONEG and a Northern New England compact (Vermont, New Hampshire, and Maine) died in the Legislature.

The regional discussion centered around the principal impediments to the 11-state compact proposal: the host-state selection process and host state rotation. Small-volume-generating states wished to provide compensation in exchange for a guarantee that they would never be required to host a large regional facility; large-volume-generating states wanted a guarantee of host-state rotation that included the small states.

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[5] Subsequent to this meeting, the CONEG compact was adopted in Delaware, Connecticut, Maryland, and New Jersey.

[6] The Rhode Island Legislature did, subsequently, substantially adopt the Special Legislative Commission's compact version.

Some of the 11 CONEG states did not participate in the April meeting in Boston. One of these was Pennsylvania, which in June, 1984, proposed the Appalachian Compact with West Virginia, and later invited the abutting states of Delaware and Maryland to join.

Compact Proposal Finalized

In May, 1984, the Special Commission unanimously approved resolutions recommending that the Governor continue discussions with other northeastern states. In September of that year, after further refinements were made to its draft, the Special Commission officially presented its compact proposal to the Governor for use in these negotiations. Appendix 6B contains the Special Commission proposal along with a summary of its major provisions.

The Special Commission then turned its attention back to another of its important charges: to develop recommendations for a state law providing for the comprehensive management of LLRW, including a process for siting any storage, treatment or disposal facilities which may be necessary in the Commonwealth. The commission's final report, issued in January, 1986, recommended the passage of an LLRW Management Act, which was adopted in 1987 as Chapter 111H.

Negotiations Conducted by EOEA

From September, 1984, when the Special Commission presented its compact draft to Governor Dukakis, until the Management Board was appointed in July, 1988, all compacting negotiations were handled for the Governor by staff of the Executive Office of Environmental Affairs (EOEA). The Governor was informed of discussions held with other states, but no formal agreements or initiatives resulted.

Most of the negotiations were conducted on an informal basis. That is, discussions occurred via telephone calls and at meetings on LLRW-related issues. According to former EOEA officials involved in these discussions, Massachusetts pursued a number of possible compact options:

- Establish a tri-state compact with New York and Pennsylvania.
- Negotiate an interim storage agreement with New York for the use of the old West Valley LLRW site.
- Establish a two-state compact with Pennsylvania, which would build a disposal facility for Classes A and B waste, while Massachusetts would build a facility for Class C waste.
- Establish a four-state compact with Maine, New Hampshire, and Vermont.
- Establish a compact with Texas with the understanding that Texas would build a facility for its LLRW, and Massachusetts would build a facility for Massachusetts LLRW. The reasoning behind this option was to exclude waste from outside of Massachusetts, a provision authorized to compacting states under federal law.

The only formal negotiations, in which meetings were established for the purposes of discussing possible compacting arrangements, were held between Massachusetts and the three northern states of Maine, New Hampshire, and Vermont. Those meetings were organized around two subjects: decommissioning and liability.

6.3 Negotiations Conducted After the Establishment of the Management Board

Chapter 111H provides that the first Management Board chairman was to be appointed by the Governor, and subsequent chairmen are to be elected annually from among the Board's members. [Chapter 111H, section 3(c)] Upon making the initial Board appointments, Governor Dukakis selected his Secretary of Environmental Affairs, James Hoyte, to fill the chairman function. Assistant Secretary Stephen Roop represented Secretary Hoyte on the Management Board, and also served as chairman.

Management Board Chairman Roop was also the individual designated by Secretary Hoyte to conduct negotiations on regional LLRW solutions. He and his staff conducted the formal discussions on decommissioning and liability with officials of Maine, New Hampshire, and Vermont. Additionally, in his capacity as a member, and chairman, of the Management Board, he fulfilled the statutory responsibility for negotiating interstate agreements assigned to the Management Board by St. 1987 c. 549, section 6.

Between July, 1988, when the first Board members were appointed, through November, 1989, when they hired an executive director, no other Board member besides Mr. Roop participated in negotiations with other states.

In November, 1989, the Management Board wrote to all of the regional compact commissions and their siting states, inquiring whether any capacity in the new regional facilities "may become available to Massachusetts generators, on either an interim or a permanent basis." Also asked were the following additional questions:

- Can your facility operator, under present circumstances, enter into contractual arrangements with Massachusetts generators to accept LLRW generated in Massachusetts?
- Will your compact entertain a proposal to allow waste from Massachusetts to be accepted at your facility, either on a "pay as you go" or a "put or pay" basis?
- Would acceptance of such a proposal require a reciprocal commitment from Massachusetts to accept a proportional volume of waste from your compact region at a later time?
- Is Massachusetts currently eligible to be admitted as a member of your compact, or would your member states be willing to amend your compact agreement to allow membership by Massachusetts?

Table 6-1 summarizes the responses to these inquiries from the siting states and compact commissions. The responses were not encouraging, as is discussed in Chapter 15 regarding the availability of facilities within and without the state.

As a result, the Management Board adopted a strategy of conducting informal discussions in order to keep communications open, and to lobby for changes in the policies of the various "siting" states and compact regions. Numerous telephone conversations occurred between the Board's executive director, representing Massachusetts, and the following states:

- California
- New York
- Maine
- Texas
- New Hampshire
- Connecticut
- Rhode Island
- Nebraska
- Vermont
- New Jersey

Table 6-1
Siting States' Responses to Accepting MA LLRW

Siting State	Response to November, 1989, Inquiry by Management Board	Current Response (as of December, 1993)
California	Interested in reciprocal agreement whereby MA would accept all CA mixed waste, and CA would take other LLRW.	Compact Commission recently voted not to accept any out-of-region LLRW.
Connecticut	As member of Northeast Compact, CT could not allow access to MA without support of other compact state. MA, or its generators, may petition for compact membership; wishes to maintain a dialogue with MA.	CT officials oppose acceptance of out-of-state waste; wish to maintain dialogue with MA in hopes MA will take CT LLRW. CT state law prohibits CT member to Compact Commission from approving importation of MA LLRW without written approval from chief elected official of CT site community (not yet determined).
Illinois	Central Midwest Commission policy opposes LLRW importation. MA is not eligible to join the Compact.	Compact Commission has banned the import of out-of-region LLRW for disposal, but will allow out-of-state LLRW for treatment.
Maine	No response.	Maine law prohibits acceptance of out-of-state LLRW for disposal. Maine is joining Texas Compact.
Nebraska	No response.	Compact law prohibits waste importation unless authorized by Compact Commission, which currently opposes.
New Jersey	No indication of support to accept MA LLRW for disposal. Wishes to maintain dialogue with MA.	New Jersey officials oppose out-of-state waste acceptance; wish to maintain dialogue with MA.
New York	No response.	State law prohibits import of LLRW for disposal.
North Carolina	As member of Southeast Compact Commission, the Commission determines importation policy. If MA wishes to join compact, it must agree to host next regional facility site.	New law allows continued access to Barnwell, S. Carolina disposal site, through June, 1994. That site intended to be closed in 1995.
Ohio	No response. (Ohio was not a "siting" state at that time)	Compact law allows importation of out-of-region waste by majority vote of Compact Commission, including affirmative vote of the Commissioner from Ohio. Ohio officials currently oppose waste importation.
Pennsylvania	Cannot accept out-of-region waste unless Compact Commission enters a reciprocal agreement to accept equal amounts of LLRW in return.	Compact law prohibits MA from joining region. Compact Commission opposes importation of out-of-region LLRW.
Texas	No response	Compact law allows importation of out-of-region LLRW by majority vote of Compact Commission. Texas officials currently oppose importation from large-generating states.
Vermont	No inquiry sent.	State officials publicly opposed to accepting out-of-state waste. Vermont is joining Texas compact.

Sources: Management Board letters to siting states, 1989; conversations with officials in each of the siting states, 1993.

Among the possible options discussed were:

- A suggestion that California would be willing to take all non-mixed LLRW into its disposal facility, if Massachusetts would accept for disposal all of the Southwest Compact region's mixed waste -- that small portion of the LLRW stream that contains, or exhibits the characteristics of, hazardous waste. California officials proposed this option in a letter to the Management Board in December, 1989.

- The possibility of contracting with the State of Texas. This option was more viable until 1991, when the Texas Legislature approved a law to allow Texas to negotiate only with other small-volume-generating states for the use of its facility, and to accept from out of state only 20% or less of the LLRW volume Texas produces in state over a 50-year period. In 1992, Texas approved legislation establishing a regional compact with Maine and Vermont, whose LLRW volumes match the 20% limit. Texas compact law does allow importation of out-of-region LLRW through contracts, by a majority vote of the Compact Commission. Texas officials have indicated no current desire to contract with large volume-generating states like Masssachusetts or Connecticut for the use of the new Texas disposal site, once it opens.

- The establishment of a regional compact involving Massachusetts, Maine, New Hampshire, Connecticut, New Jersey, New York, Rhode Island, and Vermont, or only a few of those states. None of Massachusetts potential compacting partners have indicated any willingness to host a regional facility, however.

- The establishment of a regional compact with Texas in which both Texas and Massachusetts build in-state facilities for their own LLRW, but due to compacting, do not have to fear the legal issue of forced importation from outside the compact region.

Table 6-1 also lists the current positions of the various "siting" states regarding the acceptance of LLRW from Massachusetts.

6.4 Feasibility of Regional Compacting

In approving the LLRWPA, Congress offered a major incentive to states that provided LLRW disposal through interstate compacts. The federal Act includes a provision that any host state in an interstate compact may "restrict the use of the regional disposal facilities under the compact to the disposal of LLRW generated within the region." [42 U.S.C. 2021d] This statement indicates that Congress has assumed that an individual, non-compact state does not have the same right to limit access to a state facility to wastes generated within its borders,[7] even though the federal law does not contain an explicit prohibition against such a limit.

The question of whether out-of-state or out-of-region waste can be constitutionally excluded from an LLRW facility is not necessarily resolved by the language in the Act.[8] Some legal opinions have questioned whether such an exclusion, even if part of a regional compact that was approved by Congress,

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[7] Miyares, J.R. "Report of Legal Analysis and Opinions," Massachusetts Special Legislative Commission on Low-Level Radioactive Waste, Boston, MA, April, 1984.

[8] Ibid.

could still be found in violation of the Constitution. The approval of Congress, therefore, may not always protect against a constitutional violation.[9]

It is also possible that an exclusion by a non-compact state in the use of its disposal facility could be upheld in the courts. However, legal opinion is that the "go-it-alone" option "is more likely to engender constitutional opposition than the regional compact strategy."[10] This legal concern suggests that Massachusetts cannot follow the non-compact siting option with any assurance that it would be entitled to prohibit access to out-of-state waste.

Besides the ability to restrict out-of-compact waste at a regional compact disposal site, compacting may fulfill other favorable objectives. For example, if Massachusetts were a member of a regional compact:

- The Commonwealth may not necessarily be selected as the initial host state;

- The costs of disposal facility development, operation, closure, and institutional control could be shared by all LLRW generators in the region, thereby reducing these expenses to Massachusetts generators;

- As a party state (not the host state) in a compact, Massachusetts would have some oversight ability to influence regional LLRW management policies, such as those to ensure environmental protection, and public health and safety throughout the operational, closure, and institutional control periods of any regional facility.

- If the compact's disposal facility were sited in a state located near Massachusetts, the transportation costs for Massachusetts LLRW generators most likely would be lower than the costs of transporting waste to disposal sites farther away.

- If the compact disposal site were located in another party state besides Massachusetts, public acceptance in Massachusetts would be substantial.

Participation in a regional compact can also have its negative aspects. The obvious negative features include:

- The selection of Massachusetts as the host state at some point.

- The likelihood of significant public opposition.

- The difficulties (political, social, economic, environmental) of siting any type of LLRW facility in the Commonwealth.

- The need to ensure continuous, accurate monitoring during facility operations, closure, and institutional control, to protect the environment and the public's health and safety.

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[9] Ibid. But see Prudential Insurance Co. v. Benjamin, 328 U.S. 408 (1946); Southern Pacific Co. v. Arizona, 325 U.S. 761 (1946): "Congress has undoubted power to redefine the distribution of power over interstate commerce. It may either permit the states to regulate the commerce in a manner which would otherwise not be permissible, [or] exclude state regulation even of matters of peculiarly local concern which nevertheless affect interstate commerce."

[10] Ibid.

- Increased transportation of LLRW shipments into Massachusetts.

With the exception of the change in public acceptance cited in the list of advantageous features, the other favorable elements of compacting would continue to exist were Massachusetts to serve as a host state for a regional compact. In addition, other advantages may include:

- The costs of identifying a disposal site could be assessed to all compact member states, thereby significantly reducing the Commonwealth's costs to fund site selection.

- Massachusetts could ensure that the most stringent environmental standards would be followed in site selection, operation, closure, and institutional control.

- The costs of building, operating, closing, and monitoring the facility during institutional control would be shared by all generators in the compact region, thus reducing costs to Massachusetts generators in a go-it-alone scenario.

- Massachusetts, as host state, could ensure that a portion of the fees collected during facility operation were designated for the benefit of the site community.

- The Commonwealth could exercise additional authority over waste packaging and transportation through an agreement with the U.S. Nuclear Regulatory Commission (NRC) and the U.S. Department of Transportation (DOT) -- the two federal agencies that regulate LLRW transportation -- allowing Massachusetts, and all other states in the compact, to conduct on-site inspections of NRC licensees in addition to their own licensees.

- The Commonwealth could impose sanctions against violators of LLRW transportation regulations from other compact party states.

- The State could ensure that public participation was a key part of the decision-making process, as it is in Chapter 111H.

- A Massachusetts disposal site would create jobs during facility construction and operation.

- A Massachusetts disposal site would enhance the economic and employment opportunities of the site community.

- The availability of a disposal facility to Massachusetts radioactive materials users would serve as an incentive to encourage business expansion in fields employing radioactive materials, and thereby enhance state revenues to benefit the Massachusetts economy.

- If Massachusetts compacted with one or more small-volume-generating states, the amount of out-of-state waste entering the facility may lessen public opposition in comparison to a Massachusetts site for a large compact region like the 11-state CONEG region.

Compacting Options

As is noted earlier in this chapter, every existing compact region in the nation has expressed an unwillingness to accept Massachusetts waste on a contract basis, or to allow Massachusetts to join their regions unless Massachusetts agrees to become the region's host state. Although the Commonwealth has rejected the idea of joining a large region once (i.e., the CONEG compact region), due to the likelihood of being chosen to host a large disposal site, the advantages of compact membership suggest that a re-assessment of that decision may be appropriate.

A more ideal compact option for Massachusetts may be the establishment of a new interstate compact between Massachusetts and one or more large-generating states, or between Massachusetts and several small generating states, that are not part of a regional compact.

Organizing a compact region with large-volume-generating states may enable Massachusetts to avoid initially serving as the first host state, although host state status may occur eventually. As noted in the discussion of the determination of need for facility siting in Chapter 15, none of the unaffiliated (i.e., non-Compact member) large-volume-generating states -- like New York and Michigan, is currently willing to site a facility for Massachusetts waste. Both are more than willing to send their waste to a Massachusetts facility, however.

In addition, compacting with a few small-volume-generating states would require Massachusetts to host the disposal site, but would keep to a minimum the amount of out-of-state waste entering the Commonwealth, and would enable Massachusetts to receive funding for facility site identification, development, operation, closure, and institutional control.

Likely state participants in a Massachusetts-large-volume-generating state compact include some or all of the following:

- Connecticut
- New Jersey
- Michigan
- New York

Even though Connecticut and New Jersey comprise the Northeast Compact, Connecticut's siting problems have forced them to begin anew to identify candidate sites; New Jersey is just beginning its site selection process. Both states are willing to dissolve their agreement if they can join a "sited" or "siting" region.

Likely state participants in a Massachusetts-small-volume-generating states compact include some or all of the following:

- District of Columbia
- New Hampshire
- Puerto Rico
- Rhode Island

Of course, a regional facility combining a small group of large- and small-volume-generating states would also be a possible compact configuration. Table 6-2 lists the average of three years of volume and radioactivity shipped for disposal for each of the states identified, above.

6.5 Recommendations on Regional Compacting

Massachusetts' ability to form a regional compact for LLRW disposal depends upon the state's willingness to host a regional facility. Several unaffiliated states (as well as the compact states of Connecticut and New Jersey) are interested in joining such a compact, if they do not have to serve as host state. A regional facility combining the waste volumes from Massachusetts and all the unaffiliated small-volume-generating states would amount to approximately 30,000 cubic feet of waste annually, not including any decommissioning waste figures. A two-state compact between Massachusetts and another large-volume-generating state would total between 63,500 and 105,000 cubic feet of waste entering the facility each year (not including decommissioning waste), as shown in Table 6-2. Any of these ranges, with the

addition of decommissioning waste from the region, translates into operable facility sizes.

The major advantages of regional compacting are the ability to exclude LLRW from outside a region, and the financial assistance that other states can offer to help fund the expensive costs of disposal facility siting, development, operation, closure, post-closure, and institutional control. Other benefits include the shared responsibility for hosting sites and the ability to allocate liability among the member states. These advantages were recognized by the Special Commission, which, following extensive study of this issue, recommended that Massachusetts negotiate with other states to establish a regional compact and regional disposal facility.

The two main disadvantages of regional compacting are the strong likelihood that Massachusetts would become the host state, and the probability that public acceptance of LLRW from outside the state would be low. The decision to compact, however, should not be based on popularity, but instead on an evaluation of the numerous public health, environmental, economic, and technical factors involved in LLRW management.

If the Management Board votes to initiate facility siting within Massachusetts, the Board will solicit formal indications of interest from both small- and large-volume-generating states identified in this chapter, and aid and advise the Governor and the EOEA Secretary in identifying mutually agreeable conditions for a regional waste disposal facility. Such an action will have allowed consideration of different compact configurations to be based upon the public review and comment of this Management Plan during statewide public meetings, and will also encourage formal indications of interest from other states.

Table 6-2
Average Volume and Radioactivity of Various States (1990-1992)
(cubic feet and curies)

State	Volume	Activity
Massachusetts[1]	67,977	73,325
Connecticut	45,328	96,009
District of Columbia	1,114	13
Michigan[2]	39,575	14,279
New Hampshire	163	1
New Jersey	49,479	32,461
New York	80,289	68,812
Puerto Rico	0	0
Rhode Island	298	1

[1] Massachusetts data is from the annual survey, Low-Level Radioactive Waste Management Board. The Massachusetts average shown here was not used to calculate the facility sizes referenced in this section. Because the average for 1990-1992 includes a significant volume of decommissioning waste -- which is not part of "normal" yearly volumes requiring disposal, the facility size calculations assume a Massachusetts annual volume of 25,000 cubic feet. This volume is consistent with the Management Board's estimate of annual LLRW volumes between 20,000-25,000 cubic feet after 1995.

[2] Michigan data is the average of two years instead of three, due to that state's loss of access to the regional disposal sites in 1991.

Source: U.S. Department of Energy, 1993.

6.6 Chapter References

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Appendix 6A: Compact Proposed for the Northeast States by the Coalition of Northeast Governors

6A.1 Summary of Major Provisions

Policy representatives from 11 northeastern states[1] met for 18 months between 1981-1983 to develop a draft compact for the management of low-level radioactive waste (LLRW) generated within their region. The Northeast draft compact was modeled after similar compacts in other regions, but modified to address specific issues and concerns of each of the 11 states.

The compact was submitted to the Governors of all 11 states in February, 1983. It contains four major provisions:

(1) It sets forth the major roles, responsibilities and obligations of the party states, the host states (where facilities are located), and the regional commission. Major responsibilities include timely development of a regional facility by a host state, and the commitment of party states and the Commission to a coordinated regional approach to LLRW management. An underlying responsibility is the good faith of each state to meet its obligations under the compact.

(2) The compact establishes the Northeast Interstate Low-Level Radioactive Waste Commission as an advisory and coordinative body to administer the compact. The Commission's role is to ensure that the states' collective interests are considered in the siting, development and management of a regional facility. It has no operational or regulatory authority over a facility. Its regulatory authority is limited to ensuring that member states comply with the compact.

(3) The compact establishes a process for selecting a state to host a facility. It does not specify how a state would site, develop, and oversee management of a regional facility, thus leaving these tasks to state and federal law.

(4) The compact sets forth the terms and conditions under which a state joins or withdraws from the compact. Reflecting the contractual basis of such a charter, it provides for penalties and sanctions, including revocation of membership, for states that fail to meet their agreed-upon obligations.

A summary of the major provisions of the CONEG compact follows.

<u>Article I. Policy and Purpose</u>. This article recognizes that under federal law, each state is

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[1] The 11 states participating in the Coalition of Northeastern Governors (CONEG) Policy Working Group which drafted this compact were Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.

responsible for the disposal of LLRW generated within its borders, and declares that in order to promote public health and safety, it is the policy of the party states to enter into a regional compact which will: provide a framework for cooperative efforts; assure proper LLRW transportation; minimize the number of facilities required to manage such waste; distribute the costs, benefits, and obligations of proper waste management equitably among the party states; and ensure the environmental and economic management of LLRW generated in the region.

Article II. Definitions. Key terms used in the compact are defined in this article.

Article III. Rights and Obligations. This article establishes certain rights and obligations of party states and host states, which are additional to the rights enjoyed by sovereign states. Items addressed under party state rights and obligations include: the right of access to regional facilities; ensuring proper packaging and transportation of waste consistent with applicable federal and state laws and regulations; information and reporting requirements; good faith performance by each state to ensure regional facilities are available; and the capability of each party state to host a regional facility and ensure its proper management.

The rights and responsibilities of each host state include: ensuring timely development, operation, and management of a regional facility; providing for reasonable fees and surcharges; ensuring sound packaging, transportation, and disposal of waste consistent with applicable federal state laws and regulations; and regular reporting to the regional commission.

This article also contains an exclusionary ban on management at a regional facility of wastes generated outside the party states after January 1, 1986. Waste generated in the region cannot be exported to facilities outside the region without approval of the Commission and the affected host states.

Article IV. The Commission. A Northeast Interstate Low-Level Radioactive Waste Commission is created, comprised of one member from each party state and two members from a host state, to be appointed by the Governor according to state procedures. The Commission is empowered to perform a variety of oversight, information-gathering, planning, and management functions pertaining to LLRW disposal within the region, and to designate (by two-thirds vote) a host state for a regional facility if no state volunteers. The Commission rules on applications of eligible and non-party states to become party states, and may invoke penalties and sanctions, including revocation of membership, on states which fail to fulfill their obligations. It and the host states determine whether waste can be imported into or exported from the region.

The Commission may mediate disputes among party states, negotiate agreements with other compacts, and act as an intervenor on behalf of party states. It must adopt procedural regulations to ensure efficient operation and protection of due process. Meetings of the Commission are to be open to the public. It is separate from the party states and not liable for actions of the party states, nor a facility operator. The Commission would be financed initially by a $70,000 payment from each party state, and subsequently through a special surcharge on users of the regional facility (or facilities).

Article V. Host State Selection and Development and Operation of Regional Facilities. This article establishes basic procedures for selection of a host state and for development of a regional facility. The Commission must develop a regional management plan for determining the type and number of regional facilities. Following a review, the Commission may designate a state volunteering to host a facility.

If no state volunteers, the Commission adopts procedures and criteria for designating a host state, based on statutory selection criteria. These are limited to health, safety, and welfare; environmental, economic, and social effects of a regional facility; benefits and costs; waste volumes and types generated in each party state; minimization of waste transportation; and existence of regional facilities in a party state.

A host state is responsible for timely identification of a site, and timely development and operation of a facility. It oversees management of the facility, but must solicit comments from party states and the Commission on its management of the facility. A host state must provide notice of any emergency, temporary, or scheduled closure of a facility. Fees and surcharges (for host state regulatory programs, post-closure and institutional control funds, compensation, and incentives) must be reasonable, equitable, and approved by the host state with comment by the Commission.

Article VI. Other Laws and Regulations. The legal parameters of the compact and its relationship to state laws and regulations are defined by this article. Party states are prohibited from passing any law which are inconsistent with the provisions of the compact, without jeopardizing their membership status. All existing state laws and regulations of the state or its subdivision which are inconsistent with the compact are declared null and void, and any provisions which prohibit, suspend, or unreasonably delay or restrict the designation, siting, or licensing of a regional facility are prohibited and repealed by ratification of the compact. The compact does not abrogate or limit the regulatory authority of the U.S. Nuclear Regulatory Commission or an Agreement State under Section 247 of the Atomic Energy Act of 1954, as amended.

Article VII. Eligible Parties, Withdrawal, Revocation, Entry into Force, Termination. States initially eligible to join the compact include Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont. The initial eligibility status expires June 30, 1984. Procedures and requirements for an "eligible state" to become a "party state" are set forth in this article, as are procedures for withdrawal and revocation of "party state" status. The compact will take initial effect upon enactment into law by at least three states, but will not take full effect until ratified by Congress. Congress may withdraw its consent every five years.

Article VIII. Penalties. Each state shall prescribe and enforce penalties for violations of the compact in accordance with its own laws. Importation or exportation of waste without Commission approval is prohibited. The states are responsible for enforcing violations of the law, but the Commission may seek enforcement or remedies as provided in the compact.

Article IX. Compensation Provisions. The host state must ensure that funds and procedures are available during the operating and post-closure periods to compensate injured parties and property damage (excluding property diminution) and to provide for cleanup and restoration. The obligation may be imposed on the facility operator, assumed by the state, or both.

The Commission is to provide a means of compensation to persons injured or property damaged during the institutional control period, due to the radioactive and waste management nature of the regional facility. The fund, based upon a users' surcharge, is also available for third party relief during operational and post-closure periods, but only to the extent that other resources and means are not available from the host state or other entities. Liability is limited to no more than the amount contained in the fund.

Article X. Severability and Construction. This article contains legal "boiler plate" language to assure that if any provision of the compact is invalidated by the courts, the remaining provisions shall remain in full force and effect. Guidance is also given for liberal construction of specific compact provisions.

6A.2 CONEG Compact Language

The CONEG draft compact is presented in its entirety on the following pages.

Article I. Policy and Purpose

There is hereby created the Northeast Interstate Low-Level Radioactive Waste Management Compact. The party states recognize that the Congress has declared that each state is responsible for providing for the availability of capacity, either within or outside its borders, for the disposal of low-level radioactive waste generated within its borders, except for waste generated as a result of atomic energy defense activities of the federal government, as defined in the Low-Level Radioactive Waste Policy Act (P.L. 96-573, "The Act"), or federal research and development activities. They also recognize that the management of low-level waste is handled most efficiently on a regional basis. The party states further recognize that the Congress of the United States, by enacting the Act has provided for and encouraged the development of regional low-level radioactive waste compacts to manage such waste. The party states recognize the long-term, safe and effective management of low-level radioactive waste generated within the region requires that sufficient capacity to manage such waste be properly provided.

In order to promote the health and safety of the region, it is the policy of the party states to: enter into a regional low-level radioactive waste management compact as a means of facilitating an interstate cooperative effort, provide for proper transportation of low-level waste generated in the region, minimize the number of facilities required to effectively and efficiently manage low-level radioactive waste generated in the region, encourage the reduction of the amounts of low-level waste generated in the region, distribute the costs, benefits, and obligations of proper low-level radioactive waste management equitably among the party states, and ensure the environmentally sound and economical management of low-level radioactive waste.

Article II. Definitions

As used in this compact, unless the context clearly requires a different construction:

a. "commission" means the Northeast Interstate Low-Level Radioactive Waste Commission established pursuant to Article IV of this compact;

b. "custodial agency" means the agency of the government designated to act on behalf of the government owner of the regional facility;

c. "disposal" means the isolation of low-level radioactive waste from the biosphere inhabited by man and his food chains;

d. "facility" means a parcel of land, together with the structures, equipment and improvements thereon or appurtenant thereto, which is used or is being developed for the treatment, storage or disposal of low-level waste, but shall not include on-site treatment or storage by a generator;

e. "generator" means a person who produces or processes low-level waste, but does not include persons who only provide a service by arranging for the collection, transportation, treatment, storage or disposal of wastes generated outside the region;

f. "high-level" waste means (1) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentration; and (2) any other highly radioactive material determined by the federal government as requiring permanent isolation;

g. "host state" means a party state in which a regional facility is located or being developed;

h. "institutional control" means the continued observation, monitoring, and care of the regional facility following transfer of control of the regional facility from the operator to the custodial agency;

i. "low-level waste" means radioactive waste that (1) is neither high-level waste nor transuranic waste, nor spent nuclear fuel, nor byproduct material as defined in section 11e (2) of the Atomic Energy Act of 1954 as amended; and (2) is classified by the federal government as low-level waste, consistent with existing law; but does not include waste generated as a result of atomic energy defense activities of the federal government, as defined in P.L. 96-573, or federal research and development activities;

j. "party states" means any state which is a signatory party in good standing to this compact;

k. "person" means an individual, corporation, business enterprise or other legal entity, either public or private and their legal successors;

l. "post-closure observation and maintenance" means the continued monitoring of a closed regional facility to ensure the integrity and environmental safety of the site through compliance with applicable licensing and regulatory requirements; prevention of unwarranted intrusion, and correction of problems;

m. "region" means the entire area of the party states;

n. "regional facility" means a facility as defined in this section which has been designated or accepted by the Commission;

o. "state" means a state of the United States, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands or any other territory subject to the laws of the United States;

p. "storage" means the holding of waste for treatment or disposal;

q. "transuranic waste" means waste material containing radionuclides with an atomic number greater than 92 which are excluded from shallow land burial by the federal government;

r. "treatment" means any method, technique or process, including storage for decay, designed to change the physical, chemical or biological characteristics or composition of any waste in order to render such waste safer for transport or disposal, amenable for recovery, convertible to another usable material or reduced in volume;

s. "waste" means low-level radioactive waste as defined in this section;

t. "waste management" means the storage, treatment, transportation, and disposal, where applicable, of waste.

Article III Rights and Obligations

a. There shall be provided within the region one or more regional facilities which, together with such other facilities as may be made available to the region, will provide sufficient capacity to manage all wastes generated within the region.

    1. Regional facilities shall be entitled to waste generated within the region, unless otherwise provided by the Commission. To the extent regional facilities are available, no waste generated within a party state shall be exported to facilities outside the region unless such exportation is approved by the Commission and the affected host state(s).

2. After January 1, 1986, no person shall deposit at a regional facility waste generated outside the region, and further, no regional facility shall accept waste generated outside the region, unless approved by the Commission and the affected host state(s).

b. The rights, responsibilities and obligations of each party state to this compact are as follows:

1. Each party state shall have the right to have all wastes generated within its borders managed at regional facilities, and shall have the right of access to facilities made available to the region through agreements entered into by the Commission pursuant to Article IV(i)(11). The rights of access by a generator within a party state to any regional facility is limited by the generator's adherence to applicable state and federal laws and regulations and the provisions of this compact.

2. To the extent not prohibited by federal law, each party state shall institute procedures which will require shipments of low-level waste generated within or passing through its borders to be consistent with applicable federal packaging and transportation regulations and applicable host state packaging and transportation regulations for management of low-level waste; provided, however, that these practices shall not impose unreasonable, burdensome impediments to the management of low-level waste in the region. Upon notification by a host state that a generator, shipper, or carrier within the party state is in violation of applicable packaging or transportation regulations, the party state shall take appropriate action to ensure that such violations do not recur.

3. Each party state may impose reasonable fees upon generators, shippers, or carriers to recover the cost of inspections and other practices under this compact.

4. Each party state shall encourage generators within its borders to minimize the volumes of waste requiring disposal.

5. Each party state has the right to rely on the good faith performance by every other party state of acts which ensure the provision of facilities for regional availability and their use in a manner consistent with this compact.

6. Each party state shall provide to the Commission any data and information necessary for the implementation of the Commission's responsibilities, and shall establish the capability to obtain any data and information necessary to meet its obligation as herein defined.

7. Each party state shall have the capabllity to host a regional facility in a timely manner and to ensure the post-closure observation and maintenance, and institutional control of any regional facility within its borders.

8. No non-host party state shall be liable for any injury to persons or property resulting from the operation of a regional facility or the transportation of waste to a regional facility; however; if the host state itself is the operator of the regional facility, its liability shall be that of any private operator.

c. The rights, responsibilities and obligations of a host state are as follows:

1. To the extent not prohibited by federal law, a host state shall ensure the timely development and the safe operation, closure, post closure observation and maintenance, and institutional control of any regional facility within its borders.

2. In accordance with procedures established in Article V and IX, the host state shall provide for the establishment of a reasonable structure of fees sufficient to cover all costs related to the

development, operation, closure, post-closure observation and maintenance and institutional control of a regional facility. It may also establish surcharges to cover the regulatory costs, incentives, and compensation associated with a regional facility; provided, however, that without the express approval of the Commission, no distinction in fees or surcharges shall be made between persons of the several states party to this compact.

3. To the extent not prohibited by federal law, a host state may establish requirements and regulations pertaining to the management of waste at a regional facility; provided, however, that such requirements shall not impose unreasonable impediments to the management of low-level waste within the region. Nor may a host state or a subdivision impose such restrictive requirements on the siting or operation of a regional facility that, alone or as a whole, they serve as unreasonable barriers or prohibitions to the siting or operation of such a facility.

4. Each host state shall submit to the Commission annually a report concerning each operating regional facility within its borders. The report shall contain projections of the anticipated future capacity and availability of the regional facility, a financial audit of its operation, and other information as may be required by the Commission; and in the case of regional facilities in institutional control or otherwise no longer operating, the host states shall furnish such information as may be required on the facilities still subject to their jurisdiction.

5. The host state shall notify the Commission immediately if any exigency arises which requires the permanent, temporary, or possible closure of any regional facility located therein at a time earlier than projected in its most recent annual report to the Commission. The Commission may conduct studies, hold hearings, or take such other measures to ensure that the actions taken are necessary and compatible with the obligations of the host state under this compact.

Article IV. The Commission

a. There is hereby created the Northeast Interstate Low-Level Radioactive Waste Commission. The Commission shall consist of one member from each party state to be appointed by the Governor according to procedures of each party state, except that a host state shall have two members during the period that it has an operating regional facility. The governor shall notify the Commission in writing of the identity of the member and one alternate, who may act on behalf of the member only in the member's absence.

b. Each Commission member shall be entitled to one vote. No action of the Commission shall be binding unless a majority of the total membership casts their vote in the affirmative.

c. The Commission shall elect annually from among its members a presiding officer and such other officers as it deems appropriate. The Commission shall adopt and publish, in convenient form, such rules and regulations as are necessary for due process in the performance of its duties and powers under this compact.

d. The Commission shall meet at least once a year and shall also meet upon the call of the presiding officer, or upon the call of a party state member.

e. All meetings of the Commission shall be open to the public with reasonable prior public notice. The Commission may, by majority vote, close a meeting to the public for the purpose of considering sensitive personnel or legal matters. All Commission actions and decisions shall be made in open meetings and appropriately recorded. A roll call vote may be required upon request of any party state or the presiding officer.

f. The Commission may establish such committees as it deems necessary.

g. The Commission may appoint, contract for, and compensate such limited staff as it determines necessary to carry out its duties and functions. The staff shall serve at the Commission's pleasure irrespective of the civil service, personnel or other merit laws of any of the party states or the federal government and shall be compensated from funds of the Commission.

h. The Commission shall adopt an annual budget for its operations.

i. The Commission shall have the following duties and powers:

1. The Commission shall receive and act on the application of a non-party state to become an eligible state in accordance with Article VII(e).

2. The Commission shall receive and act on the application of an eligible state to become a party state in accordance with Article VII(b).

3. The Commission shall submit an annual report to and otherwise communicate with the governors and the presiding officer of each body of the legislature of the party states regarding the activities of the Commission.

4. Upon request of party states, the Commission shall mediate disputes which arise between the party states regarding this compact.

5. The Commission shall develop, adopt and maintain a regional management plan to ensure safe and effective management of waste within the region, pursuant to Article V.

6. The Commission may conduct such legislative or adjudicatory hearings, and require such reports, studies, evidence and testimony as are necessary to perform its duties and functions.

7. The Commission shall establish by regulation, after public notice and opportunity for comment, such procedural regulations as deemed necessary to ensure efficient operation, the orderly gathering of information, and the protection of the rights of due process of affected persons.

8. In accordance with procedures and criteria set forth in Article V, the commission shall accept a host state's proposed facility as a regional facility.

9. In accordance with the procedures and criteria set forth in Article V, the Commission may designate, by two-thirds vote, host states for the establishment of regional facilities. The Commission shall not exercise this authority unless the party states have failed to voluntarily pursue the development of such facilities.

10. The Commission may require of and obtain from the party states, eligible states seeking to become party states, and non-party states seeking to become eligible states, data and information necessary for the implementation of Commission responsibilities.

11. The Commission may enter into agreements with any person, state, regional body, or group of states for the importation of waste into the region and for the right of access to facilities outside the region for waste generated within the region. Such authorization to import requires a two-thirds majority vote of the Commission, including an affirmative vote of the representatives of the host state in which any affected regional facility is located. This shall be done only after the Commission and the host state have made an assessment of the affected facilities' capability to handle such

wastes and of relevant environmental, economic, and public health factors, as defined by the appropriate regulatory authorities.

12. The Commission may, upon petition, grant an individual generator or group of generators in the region the right to export wastes to a facility located outside the region. Such grant of right shall be for a period of time and amount of waste and on such other terms and conditions as determined by the Commission and approved by the affected host states.

13. The Commission may appear as an intervenor or party in interest before any court of law, federal, state or local agency, board or commission that has jurisdiction over the management of wastes. Such authority to intervene or otherwise appear shall be exercised only after a two-thirds vote of the Commission. In order to represent its views, the Commission may arrange for any expert testimony, reports, evidence or other participation as it deems necessary.

14. The Commission may impose sanctions, including but not limited to, fines, suspension of privileges or revocation of the membership of a party state in accordance with Article VII. The Commission shall have the authority to revoke, in accordance with Article VII(g), the membership of a party state that creates unreasonable barriers to the siting of a needed regional facility or refuses to accept host state responsibilities upon designation by the Commission.

15. The Commission shall establish by regulation criteria for and shall review the fee and surcharge systems in accordance with Articles V and IX.

16. The Commission shall review the capability of party states to ensure the siting, operation, post-closure observation and maintenance, and institutional control of any facility within its borders.

17. The Commission shall review the compact legislation every five years prior to federal congressional review provided for in the Act, and may recommend legislative action.

18. The Commission has the authority to develop and provide to party states such rules, regulations and guidelines as it deems appropriate for the efficient, consistent, fair and reasonable implication of its compact.

j. There is hereby established a Commission operating account. The Commission is authorized to expend monies from such account for the expenses of any staff and consultants designated under section (g) of this Article and for official Commission business. Financial support for the Commission account shall be provided as follows:

1. Each eligible state, upon becoming a party state, shall pay $70,000 to the Commission, which shall be used for the administrative cost of the Commission.

2. The Commission shall impose a "commission surcharge" per unit of waste received at any regional facility as provided in Article V.

3. Until such time as at least one regional facility is in operation and accepting waste for management, or to the extent that revenues under paragraphs (1) and (2) of this section are unavailable or insufficient to cover the approved annual budget of the Commission, each party state shall pay an apportioned amount of the difference between the funds available and the total budget in accordance with the following formula:

(a) 20 percent in equal shares;

(b) 30 percent in the proportion that the population of the party state bears to the total population of all party states, according to the most recent census;

(c) 50 percent in the proportion that the waste generated for management in each party state bears to the total waste generated for management in the region for the most recent calendar year in which reliable data are available, as determined by the Commission.

k. The Commission shall keep accurate accounts of all receipts and disbursements. An independent certified public account shall annually audit all receipts and disbursements of Commission accounts and funds and submit an audit report to the Commission. Such audit report shall be made a part of the annual report of the Commission required by Article IV(l)(3).

l. The Commission may accept, receive, utilize and dispose for any of its purposes and functions any and all donations, loans, grants of money, equipment, supplies, materials, and services (conditional or otherwise) from any state or the United States or any subdivision or agency thereof, or interstate agency, or from any institution, person, firm or corporation. The nature, amount and condition, if any, attendant upon any donation, loan, or grant accepted pursuant to this paragraph, together with the identity of the donor, grantor, or lender, shall be detailed in the annual report of the Commission. The Commission shall by rule establish guidelines for the acceptance of donations, loans, grants of money, equipment, supplies, materials and services. This shall provide that no donor, grantor or lender may derive unfair or unreasonable advantage in any proceeding before the Commission.

m. The Commission herein established is a body corporate and politic, separate and distinct from the party states and shall be so liable for its actions. Liabilities of the Commission shall not be deemed liabilities of the party states, nor shall members of the Commission be personally liable for action taken by them in their official capacity.

1. The Commission shall not be responsible for any costs or expenses associated with creation, operation, closure, post-closure and observation and maintenance, and institutional control of any regional facility, or any associated regulatory activities of the party states.

2. Except as otherwise provided herein, this compact shall not be construed to alter the incidence of liability of any kind for any act, omission, or course of conduct. Generators, shippers and carriers of wastes, and owners and operators of sites shall be liable for their acts, omissions, conduct, or relationships in accordance with all laws related thereto.

n. The United States district courts in the District of Columbia shall have original jurisdiction of all actions brought by or against the Commission. Any such action initiated in a state court shall be removed to the designated United States district court in the manner provided by Act of June 25, 1948 as amended (28 U.S.C. section 1446). This section shall not alter the jurisdiction of the United States Court of Appeals for the District of Columbia Circuit to review the final administrative decisions of the Commission as set forth in the paragraph below.

o. The United States Court of Appeals for the District of Columbia Circuit shall have jurisdiction to review the final administrative decisions of the Commission.

1. Any person aggrieved by a final administrative decision may obtain review of the decision by filing a petition for review within 60 days after the Commission's final decision.

2. In the event that review is sought of the Commission's decision relative to the designation of a host state, the Court of Appeals shall accord the matter an expedited review, and, if the Court does not rule within 90 days after petition for review has been filed, the Commission's decision shall be

deemed to be affirmed.

3. The Courts shall not substitute their judgment for that of the Commission as to the decisions of policy or weight of the evidence on questions of fact. The Court may affirm the decision of the Commission or remand the case for further proceedings if it finds that the petitioner has been aggrieved because the finding, inferences, conclusions, or decisions of the Commission are:

   a. in violation of the Constitution of the United States;

   b. in excess of the authority granted to the Commission by this compact;

   c. made upon unlawful procedure to the detriment of any person;

   d. arbitrary or capricious or characterized by abuse of discretion or clearly unwarranted exercise of discretion.

4. The Commission shall be deemed to be acting in a legislative capacity except in those instances where it decides, pursuant to its rules and regulations, that its determinations are adjudicatory in nature.

Article V. Host State Selection and Development and Operation of Regional Facilities

a. The Commission shall develop, adopt, maintain, and implement a regional management plan to ensure the safe and efficient management of waste within the region. The plan shall include the following:

   1. a current inventory of all generators within the region;

   2. a current inventory of all facilities within the region, including information on the size, capacity, location, specific waste being handled, and projected useful life of each facility;

   3. consistent with considerations for public health and safety as defined by appropriate regulatory authorities, a determination of the type and number of regional facilities which are presently necessary and projected to be necessary to manage waste generated within the region;

   4. reference guidelines, as defined by appropriate regulatory authorities, for the party states for establishing the criteria and procedures to evaluate locations for regional facilities.

b. The Commission shall develop and adopt criteria and procedures for reviewing a party state which volunteers to host a regional facility within its borders. These criteria shall be developed with public notice and shall include the following factors: the capability of the volunteering party state to host a regional facility in a timely manner and to ensure its post-closure observation and maintenance, and institutional control; and the anticipated economical feasibility of the proposed facility.

   1. Any party state may volunteer to host a regional facility within its borders. The Commission may set terms and conditions to encourage a party state to volunteer to be the first host state.

   2. Consistent with the review required above, the Commission shall, upon a two-thirds affirmative vote, designate a volunteering party to serve as a host state.

c. If all regional facilities required by the regional management plan are not developed pursuant to section

(b), or upon notification that an existing facility will be closed, or upon determination that an additional regional facility is or may be required, the Commission shall convene to consider designation of a host state.

1. The Commission shall develop and adopt procedures for designating a party state to be a host state for a regional facility. The Commission shall base its decision on the following criteria:

   a. the health, safety and welfare of citizens of the party states as defined by the appropriate regulatory authorities;

   b. the environmental, economic, and social effects of a regional facility on the party states;

   The Commission shall also base its decision on the following criteria:

   c. economic benefits and costs;

   d. the volume and types of waste generated within each party state;

   e. the minimization of waste transportation; and

   f. the existence of regional facilities within the party states.

2. Following its established criteria and procedures, the Commission shall designate by a two-thirds affirmative vote a party state to serve as a host state. A current host state shall have the right of first refusal for a succeeding regional facility.

3. The Commission shall conduct such hearings and studies, and take such evidence and testimony as is required by its approved procedures prior to designating a host state. Public hearings shall be held upon the request in each candidate host state prior to final evaluation and selection.

4. A party state which has been designated as a host state by the Commission and which fails to fulfill its obligations as a host state may have its privileges under the compact suspended or membership in the compact revoked by the Commission.

d. Each host state shall be responsible for the timely identification of a site and the timely development and operation of a regional disposal facility. The proposed facility shall meet geological, environmental and economic criteria which shall not conflict with applicable federal and host state laws and regulations.

   1. To the extent not prohibited by federal law, a host state may regulate and license any facility within its borders.

   2. To the extent not prohibited by federal law, a host state shall ensure the safe operation, closure, post-closure observation and maintenance, and institutional control of the facility, including adequate financial assurances by the operator and adequate emergency response procedures. It shall periodically review and report to the Commission on the status of the post-closure and institutional control funds and the remaining useful life of the facility.

   3. A host state shall solicit comments from each party state and the Commission regarding the siting, operation, financial assurances, closure, post-closure observation and maintenance, and institutional control of a regional facility.

e. A host state intending to close a regional facility within its borders shall notify the Commission in writing of its intention and the reasons therefore.

   1. Except as otherwise provided, such notification shall be given to the Commission at least five years prior to the scheduled date of closure.

   2. A host state may close a regional facility within its borders in the event of an emergency or if a condition exists which constitutes a substantial threat to public health and safety. A host state shall notify the Commission in writing within three days of its action and shall, within 30 working days, show justification for the closing.

   3. In the event that a regional facility closes before an additional or new facility becomes operational, the Commission shall make interim arrangements for the storage or disposal of waste generated within the region until such time that a new regional facility is operational.

f. Fees and surcharges shall be imposed equitably upon all users of a regional facility, based upon criteria established by the Commission.

   1. A host state shall, according to its lawful administrative procedures, approve fee schedules to be charged to all users of the regional facility within its borders. Except as provided herein, such fee schedules shall be established by the operator of a regional facility, under applicable state regulations, and shall be reasonable and sufficient to cover all costs related to the development, operation, closure, post-closure observation and maintenance, and institutional control of the regional facility. The host state shall determine a schedule for contributions to the post-closure observation and maintenance, and institutional control funds. Such fee schedules shall not be approved unless the Commission has been given reasonable opportunity to review and make recommendations on the proposed fee schedules.

   2. A host state may, according to its lawful administrative procedures, impose a state surcharge per unit of waste received at any regional facility within its borders. The state surcharge shall be in addition to the fees charged for waste management. The surcharge shall be sufficient to cover all reasonable cost associated with administration and regulation of the facility. The surcharge shall not be established unless the Commission has provided reasonable opportunity to review and make recommendations on the proposed state surcharge.

   3. The Commission shall impose a commission surcharge per unit of waste received at any regional facility. The total monies collected shall be adequate to pay the costs and expenses of the Commission and shall be remitted to the Commission on a timely basis as determined by the Commission. The surcharge may be increased or decreased as the Commission deems necessary.

   4. Nothing herein shall be construed to limit the ability of the host state, or the political subdivision in which the regional facility is situated, to impose surcharges for purposes including, but not limited to, host community compensation and host community development incentives. Such surcharges shall be reasonable and shall not be imposed unless the Commission has been provided reasonable opportunity to review and make recommendations on the proposed surcharge. Such surcharge may be recovered through the approved fee and surcharge schedules provided for in this section.

Article VI. Other Laws and Regulations

a. Nothing in this compact shall be construed to abrogate or limit the regulatory responsibility or authority of the U.S. Nuclear Regulatory Commission or of an Agreement State under Section 274 of the Atomic

Energy Act of 1954, as amended.

b. The laws or portions of those laws of a party state that are not inconsistent with this compact remain in full force.

c. Nothing in this compact shall make unlawful the continued development and operation of any facility already licensed for development or operation on the date this compact becomes effective.

d. No judicial or administrative proceeding pending on the effective date of the compact shall be affected by the compact.

e. Except as provided for in Article III(b)(2) and (c)(3), this compact shall not affect the relations between and the respective internal responsibilities of the government of a party state and its subdivisions.

f. The generation, treatment, storage, transportation, or disposal of waste generated by the atomic energy defense activities of the federal government, as defined in P.L. 96-573, or federal research and development activities are not affected by this compact.

g. To the extent that the rights and powers of any state or political subdivision to license and regulate any facility within its borders and to impose taxes, fees, and surcharges on the waste managed at that regional facility do not operate as an unreasonable impediment to the transportation, treatment, or disposal of waste, such rights and powers shall not be diminished by this compact.

h. No party state shall enact any law or regulation or attempt to enforce any measure which is inconsistent with this compact. Such measures may provide the basis for the Commission to suspend or terminate a party state's membership and privileges under this compact.

i. All laws and regulations, or parts thereof of any party state or subdivision or instrumentality thereof which are inconsistent with this compact are hereby repealed and declared null and void. Any legal right, obligation, violation, or penalty arising under such laws or regulations prior to the enactment of this compact, or not in conflict with it, shall not be affected.

j. Subject to Article III(c)(2), no law or regulation of a party state or subdivision or instrumentality thereof may be applied so as to restrict or make more costly or inconvenient access to any regional facility by the generators of another party state than for the generators of the state where the facility is situated.

k. No law, ordinance, or regulation of any party state or any subdivision or instrumentality thereof shall prohibit, suspend, or unreasonably delay, limit or restrict the operation of a siting or licensing agency in the designation, siting, or licensing of a regional facility. Any such provision in existence at the time of the ratification of this compact is hereby repealed.

Article VII. Eligible Parties, Withdrawal, Revocation, Entry Into Force, Termination

a. The initial eligible parties to this compact shall be the eleven states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont. Initial eligibility will expire June 30, 1984.

b. Each state eligible to become a party state to this compact shall be declared a party state upon enactment of this compact into law by the state, repeal of all statutes or statutory provisions that pose unreasonable impediments to the capability of the state to host a regional facility in a timely manner, and upon payment of the fees required by Article IV(j)(1). An eligible state may become a party to this

compact by an executive order by the governor of the state and upon payment of the fees required by Article IV(j)(1). However, any state which becomes a party state by executive order shall cease to be a party state upon the final adjournment of the next general or regular session of its legislature, unless this compact has by then been enacted as a statute by the state and all statutes and statutory provisions that conflict with the compact have been repealed.

c. The compact shall become effective in a party state upon enactment by that state. It shall not become initially effective in the region until enacted into law by three party states and consent given to it by Congress.

d. The first three states eligible to become party states to this compact which adopt this compact into law as required in Article VII(b) shall immediately, upon the appointment of their Commission members, constitute themselves as the Northeast Interstate Low-Level Radioactive Waste Commission. They shall cause legislation to be introduced in the Congress which grants the consent of the Congress to this compact, and shall do those things necessary to organize the Commission and implement the provisions of this compact.

    1. The Commission shall be the judge of the qualifications of the party states and of its members and of their compliance with the conditions and requirements of this compact and of the laws of the party states relating to enactment of this compact.

    2. All succeeding states eligible to become party states to this compact shall be declared party states pursuant to the provisions of section (b) of this Article.

e. Any state not expressly declared eligible to become a party state to this compact In section (a) of this Article may petition the Commission to be declared eligible. The Commission may establish such conditions as it deems necessary and appropriate to be met by a state requesting eligibility as a party state to this compact pursuant to the provisions of this section, including a public hearing on the application. Upon satisfactorily meeting such conditions and upon the affirmative vote of two-thirds of the Commission, including the affirmative vote of the representatives of the host states in which any affected regional facility is located, the petitioning state shall be eligible to become a party state to this compact and may become a party state in the same manner as those declared eligible in section (a) of this Article.

f. No state holding membership in any other regional compact for the management of low-level radioactive waste may become a member of this compact.

g. Any party state which fails to comply with the provisions of this compact or to fulfill its obligations hereunder may have its privileges suspended or, upon a two-thirds vote of the Commission, after full opportunity for hearing and comment, have its membership in the compact revoked. Revocation shall take effect one year from the date the affected party state receives written notice from the Commission of its action. All legal rights of the affected party state established under this compact shall cease upon the effective date of revocation, except that any legal obligations of that party state arising prior to revocation will not cease until they have been fulfilled. As soon as practicable after a Commission decision suspending or revoking party state status, the Commission shall provide written notice of the action and a copy of the resolution to the governors and the presiding officer of each body of the state legislatures of the party states, and to chairmen of the appropriate committees of the Congress.

h. Any party state may withdraw from this compact by repealing its authorization legislation, and all legal rights under this compact of the party state cease upon repeal. However, no such withdrawal shall take effect until five years after the governor of the withdrawing state has given notice in writing of such withdrawal to the Commission and to the governor of each party state. No withdrawal shall affect any

liability already incurred by or chargeable to a party prior to that time.

1. Upon receipt of the notification, the Commission shall, as soon as practicable, provide copies to the governors and the presiding officer of each body of the state legislatures of the party states, and to the chairmen of the appropriate committees of the Congress.

2. A regional facility in a withdrawing state shall remain available to the region for five years after the date the Commission receives written notification of the intent to withdraw or until the prescheduled date of closure, whichever occurs first.

i. This compact may be terminated only by the affirmative action of the Congress or by the repeal of all laws enacting the compact in each party state. The Congress may by law withdraw its consent every five years after the compact takes effect.

1. The consent given to this compact by the Congress shall extend to any future admittance of the new party states under sections (b) and (e) of this Article.

2. The withdrawal of a party state from this compact under section (h) or the revocation of a state's membership in this compact under section (g) of this Article shall not affect the applicability of the compact to the remaining party states.

Article VIII. Penalties

a. Each party state, consistent with federal and host state regulations and laws, shall enforce penalties against any person not acting as an official of a party state for violation of this compact in the party state. Each party state acknowledges that the shipment to a host state of waste packaged or transported in violation of applicable laws and regulations can result in the imposition of sanctions by the host state. These sanctions may include, but are not limited to, suspension or revocation of the violator's right of access to the facility in the host state.

b. Without the express approval of the Commission, it shall be unlawful for any person to dispose of any low-level waste within the region except at a regional facility; provided, however, that this restriction shall not apply to waste which is permitted by applicable federal or state regulations to be discarded without regard to its radioactivity.

c. Unless specifically approved by the Commission and affected host state(s) pursuant to Article IV, it shall be a violation of this compact for: (1) any person to deposit at a regional facility waste not generated within the region; (2) any regional facility to accept waste not generated within the region; and (3) any person to export from the region waste generated within the region.

d. Primary responsibility for enforcing violations of the law will rest with the affected state or states. The Commission, upon a two-thirds vote of its members, may bring action to seek enforcement or appropriate remedies against violators of the provisions and regulations for this compact as provided for in Article IV.

Article IX. Compensation Provisions

a. The responsibility for ensuring compensation and clean-up during the operational and post-closure periods rests with the host state, as set forth herein.

1. The host state shall ensure the availability of funds and procedures for compensation of injured

persons, including facility employees, and property damage (except for any possible claims for diminution of property values) due to the existence and operation of a regional facility, and for clean-up and restoration of the facility and surrounding areas.

2. The state may satisfy this obligation by requiring bonds, insurance, compensation funds, or any other means or combination of means, imposed either on the facility operator or assumed by the state itself, or both. Nothing in this alters the liability of any person or governmental entity under applicable state and federal laws.

b. The Commission shall provide a means of compensation for persons injured or property damaged during the institutional control period due to the radioactive and waste management nature of the regional facility. This responsibility may be met by a special fund, insurance, or other means.

1. The Commission is authorized, at its discretion, to impose a waste management surcharge, to be collected by the operator or owner of the regional facility; to establish a separate insurance entity, formed by but separate from the Commission itself, but under such terms and conditions as it decides, and exempt from state insurance regulation; to contract with this company or other entity for coverage; or to take any other measures, or combination of measures, to implement the goals of this section.

2. The existence of this fund or other means of compensation shall not imply any liability by the Commission, the non-host party states, or any of their officials and staff, which are exempted from liability by other provisions of this compact. Claims or suits for compensation shall be directed against the fund, the insurance company, or other entity, unless the Commission, by regulation, directs otherwise.

c. Not withstanding any other provisions, the Commission fund, insurance, or other means of compensation shall also be available for third party relief during the operational and post-closure periods, as the Commission may direct, but only to the extent that no other funds, insurance, tort compensation, or other means are available from the host state or other entities, under section a. of this Article or otherwise; provided, that this Commission contribution shall not apply to clean-up or restoration of the regional facility and its environs during the operational and post-closure period.

d. The liability of the Commission's fund, insurance entity, or any other means of compensation shall be limited to the amount currently contained therein; provided that the Commission may set some lower limit to ensure the integrity and availability of the fund or other entity for liability.

Article X. Severability and Construction

The provisions of this compact shall be severable, and if any phrase, clause, sentence or provision of this compact is declared by a federal court of competent jurisdiction to be contrary to the Constitution of the United States or the applicability thereof to any government, agency, person or circumstance is held invalid, the validity of the remainder of this compact and the applicability thereof to any other government, agency, person or circumstance shall not be affected thereby. The provisions of this compact shall be liberally construed to give the effect to the purpose thereof.

Appendix 6B: Modified CONEG Compact Recommended by the Special Legislative Commission on LLRW

6B.1 Summary of Major Provisions

Following extensive review of the Coalition of Northeastern Governors (CONEG) compact language, which appears in Appendix 6A, the Massachusetts Special Legislative Commission on Low-Level Radioactive Waste presented a modified CONEG compact document to the Governor in September, 1984, for Massachusetts' use in negotiating a regional low-level radioactive waste (LLRW) disposal agreement. Discussions were held between various New England states, as described in Chapter 6. However, no compact agreement was achieved.

The modified CONEG compact differs from the CONEG document in two main areas:

(1) Rights and Obligations of the Host State versus Party States. The CONEG compact gives non-host party states clear advantage over the host state. The modified version, on the other hand, provides greater protection and authority to the host state, while also protecting the rights and obligations of the non-host states in the compact.

(2) Administrative Procedures for Commission Actions. The CONEG compact contained limited procedural requirements for the regional Commission. The modified compact explicitly delineates these requirements.

The modified CONEG compact also differs from the CONEG compact on issues of liability, host state selection, and LLRW management. A summary of the major provisions of the modified CONEG compact follows.

Article I. Policy and Purpose. Like the CONEG compact, this article acknowledges that under federal law, each state is responsible for the disposal of LLRW generated within its borders. The Article notes that Congress encourages the development of regional LLRW compacts to manage this waste, and that a regional compact facilitates interstate cooperation, promotes safe LLRW transportation, minimizes the number of facilities needed to manage LLRW effectively and efficiently, can assist in the reduction of waste volume requiring disposal in the region, and distributes the costs, benefits, and obligations of proper LLRW management equitably among the party states.

Article II. Definitions. Terms used in the modified CONEG compact draft are similar to those found in the CONEG document; however, procedural terms are added.

Article III. Rights and Obligations of Party States. Like the CONEG compact, Article III identifies certain rights and responsibilities of party states which are in addition to the rights enjoyed by sovereign states. These include the right of access to regional LLRW facilities; each state's legal capability to host a regional facility in a timely manner and to ensure its proper operation; the responsibility to ensure proper LLRW packaging and transportation; information reporting requirements; and the right to rely on the good

faith performance of each state in the compact.

Article IV. Rights and Obligations of Host States. The state hosting an LLRW facility has certain rights and responsibilities beyond those of the party states. These include ensuring the timely development, management, and financial stability of regional facilities within its borders; protecting the health, safety and welfare of host state citizens; imposing reasonable fees and surcharges on the users of a regional facility; notifying the compact commission in the event of closing a facility prior to its scheduled closing date; and reporting to the compact commission on fees, future capacity, facility monitoring, and the Facility Closure Plan.

Article V. The Commission. The draft proposes a regional Commission comprised of one member from each party state, and two members from a host state during the period that it has an operating regional facility. Each Commission member shall be entitled to one vote; except that when a host state with a closed regional facility is represented by only one member, that member shall be entitled to two votes if the Commission takes any action affecting that facility.

The Commission's duties include monitoring the activities of all regional facilities; selecting host states by a two-thirds vote; entering into agreements for the import and export of LLRW; and imposing sanctions on party states.

Article VI. Host State Selection and Regional Facility Development. The selection of a host state follows specific procedures in the compact draft:

(1) development of a Regional LLRW Management Plan which includes a determination of need for the type and capacity of regional facilities;

(2) adoption of interim and emergency storage plans;

(3) selection of up to two states that will successively host a regional facility; and

(4) a procedure for mapping and screening the entire region in the event that no state assumes the responsibility as facility host. The draft provides that any party state, whose entire land area is eliminated from consideration during the regional mapping and screening, shall be excluded from further consideration for hosting a regional facility.

The Special Commission that drafted the modified CONEG compact draft proposed four options for consideration in finalizing the host state selection procedure. Each would follow the regional screening process. They are:

(1) The compact Commission would randomly pick a host state from among the entire group of environmentally eligible party states, as determined by the screening process.

(2) Each environmentally eligible party state would select a site within its borders, and an independent consultant would choose the most suitable site from among the potential sites.

(3) The compact Commission would adopt procedures for host state selection using environmental, health, and safety factors from the regional screening process, as well as other considerations, such as the existence of an adequate transportation network, each state's capacity to oversee the management and regulation of a regional facility, and each state's contribution to the region's total LLRW volume and curie content.

(4) Host state responsibility would be rotated among the party states in order of their relative

contribution to the total LLRW volume and curie content.

Article VII. Other Laws and Regulations. Like the CONEG document, this article describes the legal parameters of the compact and its relationship to state laws and regulations. The draft does not abrogate or limit the regulatory authority of the U.S. Nuclear Regulatory Commission or an Agreement State. The provision in the CONEG version, which nullifies state laws determined to be inconsistent with the compact, is removed from the modified CONEG compact. In its place is a provision that no law or regulation of a party state may be applied so as to restrict or make more costly or inconvenient access to any regional facility by the generators of another party state than for the generators of the host state.

Article VIII. Conditions of Membership. This article replaces Article VII of the CONEG compact. It establishes dates for initial eligibility, and requires only two states to enact the compact, rather than CONEG's three-state condition.

Article IX. Enforcement. Primary responsibility for enforcing the compact rests with the affected states, but the compact commission could seek enforcement measures by a two-thirds vote of its members.

Article X. Fees, Compensation and Liability. Procedures for imposing fees and assigning liability are described in this article. Provisions include:

(1) strict liability for any person who carries on an abnormally dangerous activity involving LLRW management;

(2) host state responsibility to ensure that a facility operator has available funds during facility operation, closure and post-closure periods to clean up, stabilize and restore a facility and surrounding areas, and to satisfy third party liabilities;

(3) responsibility by the custodial agency for surveillance and maintenance during the institutional control period;

(4) responsibility by all party states for the reasonable costs of cleanup, stabilization and restoration, if all other sources of funds have been exhausted; and

(5) responsibility by the compact commission to provide a means of compensation for third party injuries, if no other sources of funds are available.

Article XI. Severability and Construction. This article is similar to the CONEG compact draft, except that a reference to the Constitution of any party state is added. A prohibition against waivers of requirements authorized under the compact is also included.

6B.2 Modified CONEG Compact Draft

Article I. Policy and Purpose

There is hereby created the ________________ Interstate Low-Level Radioactive Waste Management Compact. The party states recognize that the Congress has declared that each state is responsible for providing for the availability of capacity, either within or outside its borders, for disposal of low-level waste generated within its borders, except for waste which remains a federal responsibility,

including waste generated as a result of atomic energy defense activities of the federal government, as defined in the Low-Level Radioactive Waste Policy Act, 42 U.S.C. secs. 2021b et-seq., or federal research and development activities. The party states further recognize that the Congress of the United States has provided for, and encouraged the development of, regional low-level waste compacts to manage such waste. The party states recognize that the long-term, safe and efficient management of low-level waste generated within the region requires that sufficient capacity to manage such waste be properly provided.

In order to promote public health and safety in the region, it is the policy of the party state to: enter into a regional low-level waste management compact as a means of facilitating an interstate cooperative effort; promote safe transportation of low-level waste generated in the region; minimize the number of facilities required to manage effectively and efficiently the low-level waste generated in the region; assist in the reduction of both the volume of low-level waste that must be disposed in the region, to the extent consistent with protection of public health, safety, and environment; distribute the costs, benefits, and obligations of proper low-level waste management equitably among the party states; and promote the environmentally sound and economical management of low-level waste throughout the packaging, transportation, storage, disposal, closure, post-closure observation and maintenance and institutional control periods of waste-related activity.

Article II. Definitions

As used in this compact, unless the context clearly requires a different construction:

a. "adjudicatory proceeding" means the Commission process of formulating an order;

b. "closure" means the permanent termination of waste acceptance at a facility, including closure prior to its scheduled closing date, and the implementation of a closure plan;

c. "Commission" means the ________________ Interstate Low-Level Radioactive Waste Management Commission established in Article V;

d. "Commission action" means the whole or a part of a Commission rule, order, sanction, relief or the equivalent or denial thereof, or failure to act;

e. "custodial agency" means the agency of the state or federal government designated to act on behalf of the government owner of a regional facility during the facility's institutional control period.

f. "disposal" means the isolation of low-level waste from the biosphere inhabited by human beings and their food chains;

g. "executive session" means any meeting or part of a meeting of the Commission or committee of the Commission which is closed to certain persons for deliberation on certain matters;

h. "facility" means a parcel of land, together with the structures, equipment and improvements thereon or appurtenant thereto, which is being developed, is used, or has been used for the treatment, storage or disposal of low-level waste;

i. "generator" means a person who produces or treats low-level waste in the region, but does not include persons who only provide a service by arranging for the collection, transportation, treatment, storage or disposal of low-level waste generated outside the region;

j. "high-level waste" means (1) the highly radioactive material resulting from the reprocessing of spent

nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentration; and (2) any other highly radioactive material determined by the federal government as requiring permanent isolation;

k. "host state' means a party state in which a regional facility is located or being developed;

l. "institutional control" means the continued observation, monitoring, and care of a regional facility following transfer of the facility's license from the operator to the custodial agency;

m. "interim storage" means the temporary storage of low-level waste in the event that no licensed facility is available for its treatment or disposal in the region during any time this compact is in effect;

n. "intervenor to an adjudicatory proceeding" means any party state or agency or political subdivision thereof, or not less than 50 other persons residing within the region, who petition for status as a party to an adjudicatory proceeding in which damage to the environment, the public's health or safety or economic damage, injury of financial integrity might be an issue.

o. "low-level waste" means radioactive waste that (1) is neither high-level waste nor transuranic waste, nor spent nuclear fuel, nor byproduct material as defined in section 11(e)(2) of the Atomic Energy Act of 1954, as amended, 42 U.S.C. sec. 2014(e); and (2) is classified by the federal government as low-level waste, consistent with existing law; but does not include waste which remains a federal responsibility, including waste generated as a result of atomic energy defense activities of the federal government, as defined in the Policy Act, or federal research and development activities;

p. "management" means the generation, storage, packaging, treatment, transportation, and disposal, where applicable, of low-level waste.

q. "order" means a Commission action of particular applicability that determines the legal rights, duties, privileges, immunities or other legal interests of one or more specific states or persons. The term includes, but is not limited to the following Commission actions:

   1. determination of whether or not a state is eligible for admission to the compact;

   2. determination of compliance of a party state with the conditions and requirements of the compact;

   3. designation of host states;

   4. revocation of a party state's membership in the compact; and

   5. imposition of sanctions against a party state;

r. "party state" means any state which is a signatory party in good standing to this compact;

s. "party to an adjudicatory proceeding" means (1) any person whose rights, duties or privileges are to be determined through formulation of an order; (2) any other person who, as a matter of right or by any provision of this compact, is entitled to participate fully in the proceeding and who, upon notice as required in section 1 of Article V makes appearance; and (3) any intervenor to the adjudicatory proceeding;

t. "person" means an individual, corporation, business enterprise, unincorporated association or other legal entity, either public or private, and its legal successors; and any party state, or agency or political subdivision thereof;

u. "Policy Act" means the Low-Level Radioactive Waste Policy Act, 42 U.S.C. secs. 2021b et seq.

v. "post-closure observation and maintenance" means the active monitoring and maintenance of a facility which has been closed in accordance with its license site closure plan, and in compliance with other applicable regulatory requirements in preparation for transfer of the facility's license from the operator to the custodial agency;

w. "public document" means a document which shall be available for inspection by any person during normal business hours at the office of the Commission or by other mutually agreed arrangement;

x. "region" means the entire geographic area of the party states;

y. "regional facility" means a facility that is being or has been developed pursuant to Article VI;

z. "rule" means each Commission statement of general applicability that implements, interprets, or prescribes law or policy, or describes the organization, procedure, or practice requirements of the Commission. The term includes the amendment or repeal of a prior rule, but does not include: (1) statements concerning only the internal management of the Commission and not affecting private rights or procedures available to the public; or (2) intra-Commission memoranda;

aa. "source reduction" means reducing the volume or radioactivity of low-level waste by: (1) avoiding unnecessary contamination of items during the use of radioactive materials; (2) carefully segregating radioactive waste from non-radioactive trash; (3) substituting non-radioactive isotopes or radioisotopes with shorter half-lives in certain procedures;

bb. "state" means a state of the United States, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands or any other territory subject to the laws of the United States;

cc. "storage" means the holding of low-level waste for treatment or disposal;

dd. "storage for decay" means a procedure in which certain low-level wastes with relatively short half-lives are held for natural radioactive decay in compliance with applicable federal and state regulations;

ee. "substantial evidence" means such evidence as a reasonable mind might accept as adequate to support a conclusion;

ff. "temporary closure" means the nonpermanent termination of low-level waste acceptance at a facility prior to its scheduled closing date.

gg. "transuranic waste" means waste material containing radionuclides with an atomic number greater than 92 which are excluded from near surface disposal as determined by the federal government;

hh. "treatment" means any method, technique, or process, including storage for decay, designed to change the physical, radioactive, chemical or biological characteristics or composition of low-level waste in order to render such waste safer for management, amenable for recovery, convertible to another usable material or reduced in volume;

ii. "volume reduction" means treatment of low-level waste in order to reduce the physical dimensions of the waste and the space required for disposal.

Article III. Rights and Obligations of Party States

a. Pursuant to the procedure established in Article VI, there shall be provided within the region one or more regional facilities which, together with such other facilities as may be made available to the region, will provide sufficient capacity to accept all low-level waste generated within the region, which are delivered to such facilities for management.

b. Each party state shall have the right to have all low-level waste generated within its borders managed at a regional facility or at a facility made available to the region through agreements entered into by the Commission pursuant to paragraph i(11) of Article V; provided, however, that a generator shall have the right of access to all such facilities for so long as it adheres to applicable host state and federal laws and regulations, the provisions of this compact and any requirements adopted pursuant to it.

c. Each party state shall have the legal capability to host a regional facility in a timely manner and to ensure the proper operation, temporary closure, closure, post-closure observation and maintenance, and institutional control of any regional facility within its borders.

d. To the extent not prohibited by federal law, each party state shall require shipments of low-level waste generated within, or passing through, its borders to conform to federal packaging and transportation regulations and applicable host state regulations. Upon notification by a party state or a federal agency that a generator, shipper or carrier is in violation of federal or state management regulations, the party state in which the violation occurred shall take appropriate actions to ensure that such violations are not repeated. Each party state acknowledges that the shipment to a host state of low-level waste packaged or transported in violation of applicable laws and regulations can result in the imposition of sanctions by the host state. Such sanctions may include, but are not limited to, suspension or revocation of the violator's right of access to the regional facility.

e. Each party state may impose reasonable fees upon generators, shippers or carriers pursuant to the provisions of section a of Article X.

f. Each party state shall encourage and assist generators within its borders to reduce the sources and volumes of low-level waste requiring disposal to the extent consistent with protection of public health, safety and the environment.

g. Each party state shall provide to the Commission and host state any intrastate data and information necessary for the implementation of the Commission's or host state's responsibilities, and shall establish the capability to obtain such data and information.

h. Each party state has the right to rely on the good faith performance by every other party state of the obligations created by this compact.

i. The rights granted to the party states by this compact are additional to the rights enjoyed by sovereign states.

Article IV. Rights and Obligations of Host States

a. To the extent no prohibited by federal law, a host state is responsible for protecting the health, safety and welfare of its citizens.

b. To the extent no prohibited by federal law, a host state shall assure: (1) the timely development, reasonable availability and safe operation, closure, post-closure observation and maintenance and

institutional control of any regional facility situated within its borders; and (2) the environmental and financial integrity of such regional facility.

c. Each host state in which an operating regional facility is located shall submit to the Commission annually a report concerning each such facility situated within its borders, which shall contain projections of the anticipated future capacity and availability of the regional facility to meet future needs; a financial audit and analysis of fees collected to demonstrate the financial integrity of its operation; an accounting of any and all occupational or public health and safety incidents at the facility including their resolution; a summary of procedures and findings used to monitor the facility to assure continued isolation of the low-level waste from the biosphere; and such other information as may be required by the Commission. Each host state in which a closed regional facility is located shall submit to the Commission annually a report containing such information as may be required by the Commission, including information on the financial and environmental integrity of any such facility. Any report submitted pursuant to this section shall be a public document.

d. A host state intending to close a regional facility situated within its borders shall notify the Commission in writing of its intention and the reasons for closure. Such notification may be part of its annual report.

   1. Except in the event that temporary or permanent closure of a regional facility is necessitated by a threat to public health, safety, or the environment, such notification shall be given to the Commission at least five years prior to the scheduled date of closure.

   2. A host state may close or temporarily close a regional facility situated within its borders prior to its scheduled closing date for any reason justifying temporary or permanent closure. A host state shall notify the Commission in writing within three days of its action; and shall, within 30 working days, explain the need for the closure. A facility that is closed or temporarily closed shall remain closed as long as necessary for remedial action and, in any event, throughout any period of facility clean-up and stabilization.

e. A host state may impose reasonable fees and surcharges pursuant to the provisions of section b of Article X.

f. To the extent not prohibited by federal law, a host state shall establish regulations for the operation of any regional facility situated within its borders.

g. To the extent nor prohibited by federal law, a host state shall require the operator of a regional facility situated within its borders to submit an initial Facility Closure Plan and annual updates of the plan for host state approval. Consistent with applicable regulations, the facility closure plan and its updates shall include, but no be limited to, the following:

   1. Any geologic, hydrologic, or other facility site data pertinent to the long-term containment of low-level waste.

   2. The results of any tests, experiments, or other analysis relating to closure and sealing, waste migration, or any other tests, experiments, or analysis pertinent to the long-term containment of low-level waste within the facility.

   3. Plans for decontamination and dismantlement of facility structures and stabilization of the facility to assure long-term protection of public health, safety, and the environment.

   4. Any significant new information regarding the environmental impact of closure activities and long-term performance of the facility site.

5. On-site contingency plans in the event of a temporary closure of the facility. The Facility Closure Plan and its updates shall be public documents. The party states and the Commission shall be afforded reasonable opportunity to review and comment on the Facility Closure Plan and its annual update.

h. A host state shall, after consultation with the Commission, develop guidelines to be used by party states to encourage generators to implement volume and source reduction practices.

Article V. The Commission

a. There is hereby created the ______________________ Interstate Low-Level Radioactive Waste Management Commission. The Commission shall consist of one member from each party state to be appointed according to the procedures of each party state, except that a host state shall have two members during the period that it has an operating regional facility. the Governor of each party state shall notify the Commission in writing of the identities of the member or members from that state, and of one alternate for each member, who may act on behalf of the member only in the member's absence.

b. Each Commission member shall be entitled to one vote; except that, when a host state that has a closed regional facility is represented by only one member, that member shall be entitled to two votes, when the Commission is taking action affecting that facility. Except as otherwise provided in this compact, Commission action shall require a majority of the eligible votes of Commission members. A roll call vote shall be required upon request of any member.

c. The Commission shall elect annually, from among its members, a presiding officer and such other officers as it deems appropriate. The Commission may also establish such committees as it deems necessary to carry out its duties and functions.

d. The Commission shall meet at least once a year and shall also meet upon the call of any member. Except as provided in this section, all meetings of the Commission and its committees shall be open to the public. No majority of the members of the Commission, or its committees shall meet in private for the purpose of acting on, or deliberating toward action on, any matter, except as provided in this section. No meeting of the Commission or its committees shall be closed to the public for the purpose of holding an executive session until the Commission or committee has first convened in an open session for which public notice has been given, a majority of the members have voted to go into executive session, a vote of each member has been recorded on roll call vote and entered into the minutes, and the presiding officer has announced the purpose of the executive session and has stated whether the Commission or committee will reconvene in public after the executive session. An executive session may be held only for the consideration of: (1) sensitive personnel matters; (2) sensitive litigation matters, the public disclosure of which would adversely affect the Commission's position relative to such litigation; or (3) other legal matters where preservation for the attorney-client privilege is essential. Failure to comply with the provisions of this section shall invalidate any actions, hearings or proceedings of the Commission or its committees during that meeting.

e. For each meeting of the Commission or its committees, other than a meeting called in response to a public health, safety or environmental emergency, the Commission shall make a public announcement, at least one week before the meeting, of the time, place, and subject matter of the meeting; whether it is anticipated that any agenda item will require discussion in executive session; and the name and phone number of the official designated by the Commission to respond to requests for information about the meeting.

f. The Commission and its committees shall maintain accurate records of their meetings, setting forth the

date, time, place, members present or absent, and action taken at each meeting. Such records shall become public documents; provided, that the record of any executive session may remain secret as long as its publication may defeat the lawful purposes of the executive session, but no longer. Commission and committee meetings, except those held in executive session, may be recorded by any person in attendance by means of a tape recorder or other sonic reproduction device, which does not interfere with the conduct of the meeting.

g. The Commission may appoint, contract for, compensate, or otherwise provide for such limited staff as it determines necessary to carry out its duties and functions. The staff shall serve at the Commission's pleasure irrespective of the civil service, personnel or other merit laws of any of the party states or the federal government and shall be compensated from funds of the Commission.

h. At its annual meeting, the Commission shall adopt an annual line item budget for its operations. The Commission's budget shall be a public document.

i. The Commission herein established is a body corporate and public, separate and distinct from party states and shall be liable for its own actions on the same basis as the Untied States may be liable under the Federal Tort Claims Act (28 U.S.C. sec. 2674). Liabilities of the Commission shall not be deemed liabilities of the party states. Nor shall members of the Commission be personally liable for action taken by them in their official capacity.

j. The Commission shall have the following duties and powers:

1. The Commission shall receive, and act upon, in an adjudicatory proceeding, the application of a non-party state to become an eligible state pursuant to section e of Article VIII.

2. The Commission shall submit an annual report to, and otherwise communicate with, the governor and the presiding office of each house of the legislature of each party state regarding the activities of the Commission.

3. Upon request of any party state, the Commission shall mediate disputes which arise among the party states regarding the compact.

4. The Commission shall, after consultation with host states, adopt by rule, maintain and implement a regional low-level waste management plan, in accordance with section a of Article VI. No regional facility shall be developed prior to the completion of such a management plan.

5. The Commission shall establish by rule such procedures as are necessary to ensure efficient operation and performance of its duties and functions, the orderly gathering and dissemination of information and the protection of the rights of due process of affected persons.

6. In accordance with the procedures and criteria set forth in Article VI, the Commission shall act on a party state's application to assume responsibility to host a regional facility within its borders.

7. In accordance with the procedures and criteria set forth in Article VI, the Commission may select, by a two-thirds majority of the eligible votes of Commission members, host states for the establishment of needed regional facilities.

8. After December 31, 1985, no person shall deliver low-level waste generated outside the region to a regional facility for management, and no regional facility shall accept low-level waste generated outside the region, unless such delivery and acceptance are approved by a two-thirds majority of the eligible votes of Commission members and by the Commission members representing the host

state in which the regional facility is located. Such approval shall be granted only after the host state and the Commission have made an assessment of the affected facility's capabilities to accept such wastes and of relevant environmental, economic, and public health factors.

9. Unless otherwise provided by the Commission, all low-level waste generated within the region shall be treated, stored for decay, or delivered to a regional facility or other facility licensed to accept such waste as of the effective date of this compact. No low-level waste generated within the region shall be exported to any facility outside the region unless such export is approved by a two-thirds majority of the eligible votes of Commission members and by the Commission members representing each host state in which a regional facility is available to accept such waste.

10. The Commission may appear as an intervenor or party in interest before any court of law, federal, state or local agency, board or Commission that has jurisdiction over the management of low-level waste. Such authority to intervene or otherwise appear shall be exercised only upon the vote of a two-thirds majority of the eligible votes of Commission members. In order to present its views, the Commission may arrange for legal representation, expert testimony, reports, evidence, or other participation as it deems necessary.

11. The Commission may impose sanctions, including but not limited to, fines, suspension of privileges or revocation of party state status, in accordance with the procedures set forth in section g of Article VIII.

12. The Commission shall review and comment on fees and surcharges proposed by a site operator or host state, and on any Facility Closure Plan prepared pursuant to section g of Article IV. The Commission shall hold a public hearing prior to issuing its comments pursuant to this paragraph.

13. The Commission shall review the compact legislation every five years, prior to federal congressional review provided for in the Policy Act, and may recommend legislative action.

14. The Commission shall establish a Commission operating account. The Commission shall keep accurate accounts of all receipts and disbursements. An independent certified public accountant shall annually audit all receipts and disbursements of the Commission operating account and funds, and submit an audit report to the Commission. Such audit report shall be made a part of the annual report of the Commission.

15. The Commission may accept, receive, utilize and dispose, for any of its purposes and functions, any and all donations, loans, grants of money, equipment, supplies, materials and services, conditional or otherwise, from any state or the United States or agency or political subdivision thereof, or interstate agency, or from any other person. The nature, amount and condition, if any, attendant upon any donation, loan, or grant accepted pursuant to this paragraph, together with the identity of the donor, grantor, or lender, shall be detailed in the annual report of the Commission. The Commission shall by rule establish guidelines for the acceptance of donations, loans, grants of money, equipment, supplies, materials, and services. No donor, grantor, or lender shall derive any advantage in any proceeding before the Commission.

k. The Commission shall conduct adjudicatory proceedings as the process for formulating an order, unless the order is a decision to:

   1. issue or not to issue a complaint, summons or similar accusation; or

   2. initiate or not to initiate an investigation, prosecution, or other proceeding before the Commission, another commission or agency, or a court.

l. The Commission shall conduct adjudicatory proceedings in accordance with this section. All parties to an adjudicatory proceeding shall be granted the opportunity for a Commission hearing after reasonable notice.

1. The notice shall include:

   A. a statement of the time, place, and nature of the proceeding;

   B. a statement of the legal authority and jurisdiction under which the proceeding is to be held;

   C. a reference to the particular sections of statutes, rules and provisions of this compact involved;

   D. a short and plain statement of the matters at issue.

2. Reasonable opportunity shall be granted all parties to the adjudicatory proceeding to present, and respond to, evidence and arguments on all factual and legal questions presented in the proceeding.

3. Oral proceedings or any part thereof shall be transcribed on request of any party.

4. No ex parte communications, or communications for the benefit of one side only, relevant to the merits of the adjudicatory proceeding shall be made or knowingly caused to be made to any member of the Commission, hearing officer, or other employee who is or may reasonably be expected to be involved in the decision process of the proceeding.

5. Findings of fact shall be based exclusively on the record, which shall include:

   A. all pleadings, motions, and intermediate rulings;

   B. all evidence received or considered;

   C. a statement of matters officially noticed;

   D. questions and offers of proof, objections, and rulings thereon;

   E. proposed findings and exceptions;

   F. any decision, opinion, or report by the officer presiding at the hearing;

   G. all staff memoranda or data submitted to the members of the Commission in connection with their consideration of the case.

6. Unless precluded by law, informal disposition may be made of any contested case by stipulation, agreed settlement, consent order, or default.

m. Any party state or agency or political subdivision thereof, or not less than 25 other persons residing within the region may petition the Commission requesting the promulgation, amendment, suspension, or repeal of a rule. The Commission shall prescribe by rule the form for petitions and the procedure for their submission, consideration, and disposition. Within 30 days after submission of a petition, the Commission shall in writing affirm or deny the petition, stating the reasons for its action, and may initiate rulemaking proceedings in accordance with this section.

1. Except as provided in paragraph 2 of this section, the Commission shall, prior to the adoption,

amendment or repeal of any rule:

A. give at least 30 days' notice of its intended action. Such notice shall include a statement of either the terms or substance of the intended action or a description of the subjects and issues involved, and the time, place, and manner in which interested persons may present their views thereon. The notice shall be mailed to all persons who have made a timely request of the Commission for advance notice of its rulemaking proceedings and shall be published in the Secretary of State's Office for each party state, and in at least the two newspapers with the largest circulation in each party state.

B. grant all interested persons reasonable opportunity to submit data, views or arguments, orally or in writing. In case of substantive rules, opportunity for oral hearing must be granted if requested by any party state or agency or political subdivision thereof, or by not less than 25 other persons residing within the region. The Commission shall fully consider all written and oral submissions respecting the proposed rule. Upon request made by an interested person within 30 days after adoption of a rule, the Commission shall issue a concise statement of the principal arguments for and against its adoption, incorporating therein its reasons for overruling the arguments urged against its adoption.

2. If the Commission finds that an imminent peril to the public health, safety and welfare requires adoption of a rule upon fewer than 30 days notice, and states in writing its reasons for that finding, it may proceed without prior notice or hearing or upon any abbreviated notice and hearing that it finds practicable, to adopt an emergency rule. The rule may be effective for a period of not longer than 120 days, but the adoption of an identical rule under this section is not precluded.

n. A person suffering legal wrong because of Commission action, or adversely affected or aggrieved by Commission action, may seek judicial review thereof.

1. When the Commission finds that justice so requires, it may postpone the effective date of action taken by it, pending judicial review. On such conditions as may be required and to the extent necessary to prevent irreparable injury, the reviewing court, including the court to which a case may be taken on appeal from or on application for certiorari or other writ to a reviewing court, may issue all necessary and appropriate process to postpone the effective date of a Commission action or to preserve status or rights pending conclusion of the review proceedings.

2. A petition for judicial review under this paragraph may be heard in a court of competent jurisdiction.

3. To the extent necessary to decision and when presented, the reviewing court shall decide all relevant questions of law, interpret constitutional and statutory provisions, and determine the meaning or applicability of the terms of a Commission action. The reviewing court shall--

A. compel the Commission action unlawfully withheld or unreasonably delayed; and

B. hold unlawful and set aside Commission action, findings, and conclusions found, in accordance with the standards of the federal Administrative Procedure Act, 5 U.S.C. sec. 706(2), to be--

i. arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law;
ii. contrary to constitutional right, power, privilege, or immunity;
iii. in excess of statutory jurisdiction, authority, or limitations, or short of statutory right;
iv. without observance of procedure required by law;
v. unsupported by substantial evidence in a case of review of an adjudicatory decision;

vi. unwarranted by the facts to the extent that the facts are subject to trial de novo by the reviewing court.

In making the foregoing determinations, the court shall review the whole record or those parts of it cited by a party, and due account shall be taken of the rule of prejudicial error. The court shall not substitute its judgment for that of the Commission as to decisions of policy or weight of the evidence or questions of fact.

Article VI. Host State Selection and Development of Regional Facilities

a. The Commission shall, after consultation with host states, adopt by rule, maintain, and implement a regional low-level waste management plan to provide for safe and efficient management within the region. The plan shall be reviewed annually and revised by rule, as necessary, every five years. The Commission may retain consultants to assist in developing the plan, and shall gather necessary data in cooperation with appropriate agencies in each party state. The primary consideration guiding the development of the plan shall be the protection of public health, safety and the environment. The plan shall include, but not be limited to:

 1. a classification system for all low-level wastes based on characteristics including, but not limited to, radiological half-life, radiological toxicity, chemical toxicity, and physical form of the waste;

 2. an inventory of all generators within the region, including information on: the location of the generator; its products, services, clinical procedures, teaching or research activities; the number of full-time-equivalent employees involved in these activities; current and projected low-level waste volume, characteristics and curies; current and projected management activities including on-site storage and storage for decay capabilities; and packaging and transportation practices;

 3. an inventory of all regional facilities, including information on the size, capacity, location, and projected operating life of each facility, and the waste being handled at each facility;

 4. consistent with considerations for the protection of public health, safety, and the environment, a determination of the type and capacity of regional facilities that are necessary or projected to be necessary to accept the low-level waste generated within the region for management;

 5. a review and analysis of current, developing and projected regional management technologies and practices;

 6. a review and analysis of fees charged generators to ensure the safe, environmentally sound operation of each regional facility, to ensure that the licensee has sufficient insurance protection against personal injury and property damage, including third party liability insurance throughout the operation, closure, post-closure observation and maintenance, and institutional control periods; and to ensure the availability of funds for surveillance, cleanup and restoration of the surrounding area.

 7. a review and analysis of party state efforts to encourage source and volume reduction pursuant to the guidelines established by the host state or states.

b. The Commission shall adopt by rule both interim and emergency storage plans to go into effect in the event that no regional facility is operational at any time after December 31, 1985. The plans may include contractual agreements with facilities located outside the region.

 1. If the Commission determines, in accordance with the provisions of this section, that an interim

storage facility must be developed within the region, such facility must have the consent of the state in which it is located, and shall not remain in operation longer than five years without the consent of that state.

2. In the event that a regional facility closes prior to its scheduled closing date, the Commission shall:

   A. implement the interim storage and disposal plans adopted pursuant to this section; and

   B. inform the governor of the party state scheduled to host the next regional facility to bring that facility into operation;

c. The Commission shall adopt by rule criteria and procedures for approving, in an adjudicatory proceeding, a party state's application to assume responsibility to host a regional facility within its borders. These criteria shall include, but not be limited to: the capability of the party state to host a regional facility in a timely manner and to ensure its operation for a 20-year period, temporary closure, closure, post-closure observation and maintenance, and institutional control in a manner consistent with protecting the public health and safety and the environment; and the anticipated economic feasibility of the proposed regional facility.

d. Upon notification that an existing regional facility will be closed, or whenever the Commission has made a determination, pursuant to paragraph 4 of section a, that additional regional facility capacity is necessary or projected to be necessary, and a party state submits to the Commission, in accordance with the procedures established pursuant to section c, an application to assume responsibility for hosting a regional facility, the Commission shall conduct an adjudicatory proceeding to consider the application. Consistent with the criteria established pursuant to section c, the Commission shall act upon the vote of a two-thirds majority of the eligible votes of Commission members, either to approve or deny the application, or to make recommendations that will allow the state to receive later approval.

   1. Upon approval of a party state's application pursuant to this section, the state shall become a host state on the date specified in the approval.

   2. The Commission may approve an application, in which a party state assumes the responsibility to host a regional facility upon the closure of another regional facility, currently in development or operation, but the Commission shall not approve more than one such successor state.

e. Upon notification that an existing facility will be closed, or whenever the Commission has made a determination, pursuant to paragraph 4 of section a, that additional regional facility capacity is necessary or projected to be necessary, and no application submitted pursuant to sections c and d is pending before the Commission which, if approved, would result in the development of additional capacity adequate to accept the low-level waste generated within the region for management, the Commission shall initiate the process set forth in this section to select a state to host a regional facility in a timely manner and to ensure its operation for a 20-year period. The primary criterion guiding this process shall be the protection of public health, safety and the environment. However, no state shall be required to host two successive regional facilities.

   1. The Commission shall notify all party states, other than the host state in which the most recently developed regional facility is located, that they are potential host states for the purpose of undertaking the macroscreening review established in paragraph 2 of this section. Such notification shall be made to the governor and the presiding officer of each house of the legislature of each party state, and shall describe the process to be used to select a host state.

   2. The Commission shall, after consultation with appropriate licensing and regulatory authorities, adopt

by rule exclusionary criteria to identify all geographic areas that are unsuitable as regional facility sites. Such criteria shall exclude, at least, all geographic areas:

A. containing exploitable natural resources;

B. within a 500-year floodplain or coastal high-hazard area;

C. subject to frequent flooding or ponding or which are generally not well drained;

D. within coastal or freshwater wetlands or on a barrier beach;

E. within which is located an existing or projected public drinking water supply;

F. within the watershed of surface waters classified as class "A," pursuant to the U.S. Clean Water Act;

G. over an aquifer designated as a sole source aquifer pursuant to the U.S. Safe Drinking Water Act;

H. restricted by a party state because of their critical environmental nature;

I. in a lower drainage basin where the amount of runoff could erode or inundate a facility site;

J. where the water table is of sufficient height to allow perennial or other ground water intrusion to contact the waste;

K. where ground water is discharged to the surface;

L. where tectonic processes such as faulting, folding, seismic activity, or vulcanism may preclude defensible modeling and prediction of long-term impacts;

M. where surface geologic processes such as mass wasting, erosion, slumping, landsliding, or weathering may indicate instability;

N. where ground water intrusion, perennial or otherwise could impact the facility's ability to isolate the waste;

O. critical to the habitat of endangered or threatened species of plants or animals;

P. of historical or architectural significance. The application of such exclusionary criteria shall not be subject to waiver by the consultant or the Commission.

3. The Commission shall retain the services of an independent consultant to map and macroscreen each potential host state in the region in accordance with the criteria adopted pursuant to paragraph 2 of this section. The independent consultant shall consider recommendations and comments from any person, and shall hold public meetings in each potential host state to accept such recommendations and comments. Notice of such public meetings shall be made at least 14 days in advance, and shall be published in the Secretary of State's office for the state in which the meeting is to be held, and in at least the two newspapers with the largest circulations in that state. In addition, notice shall be mailed to all persons who make timely request of the Commission for an opportunity to comment, and to the governor and the presiding officer of each house of the legislature of each potential host state.

4. Upon acceptance by the Commission of the independent consultant's report, the Commission shall transmit a copy thereof to the governor of each party state. Within 90 days of receipt of the report, the governor of each potential host state shall submit to the Commission a written response to the report.

5. If the entire land area of any potential host state has been identified in the independent consultant's report as unsuitable as a regional facility site, such state shall be excluded from further consideration for hosting a regional facility. Any party state that disputes the results contained in the independent consultant's report and believes that its entire land area is unsuitable as a regional facility site shall have the opportunity to present its objection in an adjudicatory proceeding before the Commission. This proceeding shall follow the procedures established in Article V except that:

   A. The hearing shall be conducted within the borders for the party state disputing the report's results; and

   B. A two-thirds majority of the eligible votes of Commission members shall be required to exclude the party state from further consideration for hosting a regional facility. The Commission shall commence such adjudicatory proceeding no sooner than 90 days and no later than 120 days after receipt of a state's claim that it should be excluded from further consideration for hosting a regional facility.

6. Upon expiration of the time for party states to respond to the independent consultant's report or upon the completion of the adjudicatory proceeding provided for in this section, the Commission shall issue a list of states to be excluded from further consideration for hosting a regional facility. Such list shall include both any state identified in the report as unsuitable as a regional facility site and any state which the Commission has voted to exclude from further consideration in accordance with this section. The Commission shall notify all party states not excluded by the process set forth in this section that they are potential host states. Such notification shall indicate that the state has within its boundaries a geographic area or areas that meet the environmental criteria established pursuant to paragraph 2 of this section.

Four Specific Host State Selection Options for Further Review and Consideration

Option I

7. In an open meeting, the Commission shall randomly select from among the states so notified: first, the state which shall host the next regional facility; and second, the state which shall host the next succeeding regional facility. Nothing in this paragraph shall prohibit a host state, once selected, from assuming responsibility for hosting an additional regional facility.

8. In accordance with applicable state and federal law and regulations, the two party states selected pursuant to the provisions of paragraph 7 of this section shall initiate a timely regional facility site selection process. On or before the date on which the first of these two regional facilities begins operation, the successor state shall designate a site for a regional facility, and take all measures necessary to ensure the availability of that site at the time that it will be needed.

9. A party state selected as a host state pursuant to paragraph 7 of this section, which fails to fulfill its obligations as a host state is subject to having its privileges under, or party state status in, this compact suspended or revoked by the Commission.

Option II

7. In accordance with applicable state and federal law and regulations, each state so notified shall initiate a timely regional facility site selection process. Each state shall submit to the Commission its designated site, together with an explanation why the site was chosen.

8. The Commission shall regain the services of an independent consultant to conduct an on-site investigation and review of each state's designated site. On the basis of the information thus gathered, the Commission shall determine whether each designated site is acceptable for a regional facility.

9. Any part state which has designated a site that is determined to be unacceptable shall:

   A. designate another site which satisfies the criteria established pursuant to paragraph 2 of this section; or

   B. offer evidence to the Commission that no other site exists within the borders of the state.

10. After public hearing, the Commission shall adopt by rule criteria for the purpose of comparing and ranking each acceptable designated site.

11. For each acceptable designated site, the Commission shall conduct an adjudicatory proceeding on the appropriateness of the site for a regional facility. Each such proceeding shall be held in accordance with the provisions of Article V, except that it shall be held at a location that is reasonably accessible to residents living in the vicinity of the designated site.

12. Based on the records of the adjudicatory proceedings conducted pursuant to paragraph 11 of this section, the Commission shall determine, by a majority of the eligible votes of its members:

    A. the party state in which the designated site most suitable for a regional facility is located, and shall select that state to host the next regional facility; and

    B. the party state in which the designated site next most suitable for a regional facility is located and shall select that state to host the next succeeding regional facility. Nothing in this paragraph shall prohibit a host state, once selected, from assuming responsibility for hosting an additional regional facility.

13. On or before the date on which the first of these regional facilities begins operation, the successor state shall take all measures necessary to ensure the availability of its designated site at the time that it will be needed for a regional facility.

14. A party state selected as a host state pursuant to paragraph 12 of this section, which fails to fulfill its obligations as a host state, is subject to having its privileges under, or party state status in this compact, suspended or revoked by the Commission.

Option III

7. The Commission shall adopt by rule criteria and procedures for selecting, in an adjudicatory proceeding, a host state from among those so notified. In selecting a host state, the primary consideration guiding the Commission shall be the protection of public health, safety and the environment. The Commission shall also base its selection on the following considerations:

A. The existence of a regional low-level waste or high-level waste disposal facility within the state;

B. The existence of an adequate transportation network within the state and the minimization of low-level waste transportation;

C. The potential socioeconomic impact of the regional facility on the state;

D. The state's capacity to oversee the management and regulation of a regional facility in order to ensure the site's environmental and financial integrity and protect the public health and safety;

E. The state's contribution to the total low-level waste stream based on the volume and curie content of low-level waste generated within each party state.

8. The Commission may conduct its own studies as required by the procedures established pursuant to paragraph 7 of this section. Following its established criteria and procedures, the Commission shall select, by the vote of a two-thirds majority of the eligible votes of its members, the state which shall host the next regional facility and the state which shall host the next succeeding regional facility. Nothing in this paragraph shall prohibit a host state, once selected, from assuming responsibility for hosting an additional regional facility. However, no host state shall be selected under this paragraph to host a second regional facility until all other states not excluded by the process set forth in paragraphs 1 through 5 of this section have first served as a host state.

9. On or before the date on which the first of these regional facilities begins operation, the successor state shall take all measures necessary to ensure the availability of its designated site at the time that it will be needed for a regional facility.

10. A party state selected as a host state pursuant to paragraph 8 of this section, which fails to fulfill its obligations as a host state, is subject to having its privileges under, or party state status in this compact, suspended or revoked by the Commission.

Option IV

7. The Commission shall, for each state so notified, allocate host state responsibilities, based on the average annual volume and curies shipped for disposal from each such state.

A. Beginning with 1979, the number of cubic feet shipped for disposal from each such state shall be added to the corresponding number of curies shipped for disposal to give a total volume-plus-curies figure.

B. The total volume-plus-curies figure shall be calculated for each host state for each year, beginning with 1979 through the most recent year that complete volume and curie figures exist.

C. The average annual volume-plus-curies figure shall be calculated using the figures derived pursuant to this paragraph.

8. The Commission shall select the state with the largest average annual volume-plus-curies figures, calculated in accordance with paragraph 7 of this section, as the host state for the next regional facility; and the state with the second largest average annual volume plus curie figure as the host state for the next succeeding regional facility.

9. In accordance with applicable state and federal law and regulations, the two party states selected pursuant to the provisions of paragraph 8 of this section shall initiate a timely regional facility site selection process. On or before the date on which the first of these regional facilities begins operation, the successor state shall designate a site for a regional facility, and take all measures necessary to ensure the availability of that site at the time that it will be needed.

10. Upon notification that an existing regional facility will be permanently closed, the average annual volume-plus-curies figure shall be recalculated, in accordance with paragraph 7 of this section, and the Commission shall select the state with the largest average annual volume-plus-curies figure which has not been previously selected to host a regional facility as the next successor host state, provided that, if all party states have previously been so selected, the state with the largest average annual volume-plus-curies figure shall be selected as the successor host state.

11. Nothing in paragraph 8 or 10 of this section shall prohibit a host state, once selected, from assuming responsibility for hosting an additional regional facility.

12. A party state selected as a host state pursuant to paragraph 8 or 10 of this section, which fails to fulfill its obligations as a host state, is subjected to having its privileges under, or party state status in, this compact suspended or revoked by the Commission.

Article VII. Other Laws and Regulations

a. Nothing in this compact shall be construed to abrogate or limit the regulatory responsibility or authority of the U.S. Nuclear Regulatory Commission, the U.S. Department of Transportation, the U.S. Department of Energy, any other federal agency, or any Agreement State under Section 274 of the Atomic Energy Act of 1954, as amended, 42 U.S.C. sec. 2021.

b. Except as otherwise specifically provided in this compact, the laws or portions of those laws of party states shall remain in full force.

c. Nothing in this compact shall be construed to preempt, in whole or in part, any provision of the Constitution of any party state.

d. Nothing in this compact shall make unlawful the continued development or operation of any facility already licensed for development or operation on the date this compact becomes effective.

e. No judicial or administrative proceeding pending on the effective date of this compact shall be affected by it. Any legal right, obligation, violation or penalty arising prior to the effective date of this compact, or not In conflict with it, shall not be affected by this compact.

f. Except as provided in section d of Article III, no law or regulation of a party state or an agency or political subdivision thereof may be applied so as to restrict or make more costly or inconvenient access to any regional facility by the generators of another party state than for the generators of the host state.

g. The generation, treatment, storage, transportation, or disposal of waste which remains a federal responsibility, including waste generated by the atomic energy defense activities of the federal government, as defined In the Policy Act or federal research and development activities are not affected by this compact.

Article VIII. Conditions of Membership

a. The states initially eligible to become parties to this compact shall be ______________________________
____
____
______________________________. Initial eligibility shall expire December 31, 1985.

b. Each state eligible to become a party state to this compact shall be a party state upon enactment of this compact into law by such state, and upon payment of the fees required by Article X. An eligible state may become a party to this compact by an executive order issued by the governor of the state and upon payment of the fees required by Article X. However, any state which becomes a party state by executive order shall cease to be a party state upon the final adjournment of the next general or regular session of its legislature, unless this compact has by then been enacted as a statute by such state.

c. This compact shall become effective in a party state when it has been enacted by that state and consent has been given to this compact by the Congress.

d. The first two states to become party states to this compact shall immediately appoint Commission members who shall constitute the ________________ Interstate Low-Level Radioactive Waste Commission in accordance with Article V. These party states shall cause legislation to be introduced in the Congress whereby the consent of the Congress to this compact will be granted, and shall do those things necessary to organize the Commission and implement the provisions of this compact.

e. Any state not expressly declared eligible to become a party state to this compact in section a of this Article may petition the Commission to be declared eligible. The Commission may by rule establish such conditions as it deems necessary and appropriate to be met by a state requesting eligibility as a party state to this compact pursuant to the provisions of this section, and shall conduct an adjudicatory proceeding on the application. Upon satisfying the conditions established by the Commission and upon the affirmative vote of a two-thirds majority of the eligible votes of Commission members, and the affirmative vote of the members representing the host states in which any affected regional facility is located, the petitioning state shall become eligible to become a party state to this compact and may become a party state in the same manner as those states declared eligible in section a of this Article.

f. No state holding membership in any other regional compact for the management of low-level waste may become a party state to this compact.

g. Any party state which fails to comply with the provisions of this compact or to fulfill its obligation hereunder may, upon the vote of a two-thirds majority of the eligible votes of Commission members, in an adjudicatory proceeding, have fines imposed, have its access conditioned, its privileges suspended or its status as a party state to this compact revoked. Any revocation of a party state's status shall take effect one year from the date on which the state receives written notice from the Commission of such action. The rights of access to regional facilities enjoyed by generators in the affected party state shall cease upon the effective date of the revocation. No legal obligations of that party state, arising prior to the revocation, shall cease until they have been fulfilled. As soon as practicable after a Commission action suspending or revoking party state status, the Commission shall provide written notice of the action and a copy of the resolution to the governor and the presiding officer of each house of the legislature of each party state, and to the Congress.

h. Any party state may withdraw from this compact by repealing its authorizing legislation, and such rights of access to regional facilities enjoyed by generators in that party state shall thereby terminate. However, no such withdrawal shall take effect until five years after the governor of the withdrawing state has given notice in writing of such withdrawal to the Commission and to the governor of each party state. No withdrawal shall affect any liability already incurred by, or chargeable to, a party state prior

to that time.

1. Upon receipt of such notification, the Commission shall, as soon as practicable, provide copies to the governor and the presiding officer of each house of the legislature of each party state, and to the Congress.

2. A regional facility located in a withdrawing state shall remain available to the region for five years after the date the Commission receives written notification of the state's intent to withdraw, or until the prescheduled date of closure, whichever occurs first.

   i. This compact may be terminated only by the affirmative action of the Congress or by the repeal of all laws enacting the compact in each party state. The Congress may by law withdraw its consent every five years after the compact takes effect.

1. The consent given to this compact by the Congress shall extend to any future admittance of new party states under section b of this Article.

2. The withdrawal of a party state from this compact under section h or the revocation of party state status under section g of this Article shall not affect the applicability of the compact to the remaining party states.

Article IX. Enforcement

Primary responsibility for enforcing the provisions of this compact shall rest with the affected state or states. Each party state, consistent with federal and host state regulations and laws, shall adopt and enforce laws imposing penalties on any person, not acting as an official of a party state, for violation of this compact. The Commission, upon a two-thirds majority of the eligible votes of its members, may bring action to seek enforcement or appropriate remedies against party states which violate the laws or regulations adopted pursuant to this compact.

Article X. Fees, Compensation and Liability

a. Each party state may establish reasonable fees which shall be imposed upon generators, shippers, or carriers to recover the cost of inspections and other administrative actions taken under this compact.

b. A host state may establish reasonable fees and surcharges which shall be imposed upon users of a regional facility. No distinction in fees or surcharges shall be made among persons of the several party states to this compact.

   1. A host state shall approve and periodically review operational fee schedules to be imposed on all users of the regional facility situated within its borders. One such fee schedule shall be established by the operator of the regional facility, under applicable state and federal regulations, and shall be reasonable and sufficient to cover all costs related to the development, operation, closure and post-closure observation and maintenance of the regional facility. The host state shall also establish a schedule for contributions to an institutional control fund. The party states and the Commission shall be afforded a reasonable opportunity to review and comment on all proposed fee schedules.

   2. A host state may establish an additional administrative surcharge per unit of waste received at any regional facility situated within its borders. The surcharge shall be sufficient to cover all reasonable costs associated with administrative oversight and regulation of the facility. A host state may also impose reasonable surcharges for purposes of host community compensation and development

incentives. The Commission shall be afforded a reasonable opportunity to review and comment on any proposed host state surcharge.

c. The Commission Is authorized to expend monies from the operating account established In Article V for the expenses of any staff and consultants retained pursuant to this compact, and for official Commission business. Financial support for the operating account shall be provided as follows:

1. In accordance with the provisions of section b of Article VIII, each eligible state, upon becoming a party state, shall pay ______________ to the Commission, which shall be used for administrative costs of the Commission.

2. The Commission shall impose a "Commission surcharge" per unit of waste received at any regional facility. The size of the surcharge shall be calculated by the Commission in its annual budget preparation process after a public hearing pursuant to section h of Article V. This surcharge shall be collected for the Commission by the host state.

3. Until such time as at least one regional facility is in operation and accepting waste for management, or to the extent that revenues under paragraphs (1) and (2) of this section are unavailable or insufficient to cover the approved annual budget of the Commission, each party state shall pay an apportioned amount of the difference between the funds available and the total budget in accordance with the following formula:

   A. 20 percent in equal shares;

   B. 30 percent in the proportion that the population of the party state bears to the total population of all party states, according to the most recent U.S. census;

   C. 50 percent in the proportion that the low-level waste originating In each party state bears to the total waste generated in the region for the most recent calendar year In which reliable data are available, as determined by the Commission.

d. It shall be the responsibility of each regional facility's operator or custodial agency to take all necessary steps to clean up, stabilize and restore the facility and surrounding areas whenever there has been damage to the facility or surrounding areas which may cause or contribute to a hazard to the public health or the environment. Any person who carried on an abnormally dangerous activity involving the management of low-level waste shall be subject to strict liability for harm to the person, land or property of another resulting from the activity. This strict liability shall be limited to the kind of harm, the possibility of which makes the activity abnormally dangerous.

e. During a regional facility's operational, closure and post-closure periods, the host state shall ensure the availability of funds and procedures for the facility operator to satisfy its responsibilities and liabilities under section d, and for the compensation of injured facility employees. The state may satisfy this obligation by requiring bonds, insurance or compensation funds of the facility operator, or by providing bonds, insurance or compensation funds itself, or by any other means or combination of means. The funds available to satisfy third party liability claims shall be equal to the maximum amount available from the nuclear insurance pools or other commercial insurers.

f. During a regional facility's Institutional control period, the custodial agency shall administer the institutional control funds collected pursuant to paragraph 1 of section b, for surveillance and all required maintenance of the regional facility, including any cleanup, stabilization or restoration required by section d. The custodial agency shall ensure that funds equal to the maximum amount available from the nuclear insurance pools or other commercial Insurers are available to satisfy third party liability

claims.

g. If all other sources of funds, including federal assistance, have been exhausted, all party states shall be responsible for the reasonable costs of cleanup, stabilization and restoration of a regional facility in the proportion that the low-level waste disposed of at the facility which originated in each party state bears to the total low-level waste disposed of at the facility. If the cleanup, stabilization or restoration of the facility has become necessary as the result of gross negligence by the host state in its regulatory oversight of the regional facility, each party state shall be entitled to indemnification by the host state of the funds contributed pursuant to this section.

h. The Commission shall provide a means of compensation for third party injuries to persons, land or property, which shall be available only if no other funds, insurance, tort compensation or other means of satisfying a damage judgment or settlement resulting from the management of low-level waste are available from the host state or other entities.

   1. This responsibility shall be met by a special fund, insurance, or other means. The same fund for compensation shall provide liability coverage for all subsequent and concurrent regional facilities. The Commission is authorized to take such measures as may be necessary to implement this section, including the use of a portion of the fees collected pursuant to paragraph 2 of section c to establish an independent insurance entity. Subject to host state approval, such insurance entity shall be exempt from state insurance regulations.

   2. The existence of a special fund or other means of compensation shall not imply any liability by the Commission, by the party states, or by any of their officials and staff. Claims or suits for compensation shall be directed against the fund, the insurance entity or other responsible entity.

   3. The liability of the special fund, insurance entity, or other entity shall be limited to the amount contained therein at the time a final judgment or settlement awarding damages is executed.

Article XI. Severability and Construction

a. The provisions of this compact shall be severable and if any phrase, clause, sentence or provision of this compact is declared by a court of competent jurisdiction to be contrary to the Constitution of any party state or of the United States or the applicability thereof to any government, agency, person or circumstance is held invalid, the validity of the remainder of this compact and the applicability thereof to any other government, agency, person or circumstance shall not be affected thereby. If any provision of this compact shall be held contrary to the Constitution of any state participating therein, the compact shall remain in full force and effect as to the state affected as well as to all severable matters. The provisions of this compact shall be liberally construed to give effect to the purposes thereof.

b. Nothing in this compact shall be construed to authorize the Commission or any party state to waive the provisions of the compact or the requirements adopted pursuant to it.

Chapter 7: Classifying Low-Level Radioactive Waste

7.1 Introduction

The information in Chapter 4 on the properties of the low-level radioactive waste (LLRW) generated in Massachusetts indicates the wide range of characteristics and variety of waste streams within the LLRW category. The nature of the particular type of radiation, its persistence in the environment (i.e., its half-life[1]), its concentration in the host material or the environment, its chemical and biological properties, and many other attributes are important from an LLRW management perspective. Certain combinations of these attributes may cause some LLRW to be of relatively less concern from a health and environmental standpoint. Other mixtures of characteristics may be of substantial concern, and may require significant short- or long-term protective management strategies.

Because federal law has assigned to all states the responsibilities of LLRW management and disposal, the Commonwealth of Massachusetts must have a system in place to provide detailed information on LLRW characteristics, and to serve as a framework to enable decisions to be made on suitable management techniques.

This chapter describes such a system, known as waste "classification."

7.2 Early Classification Proposals

Prior to 1983, there were two broad management categories or classifications of LLRW:

(1) those LLRW with very short half-lives or in minute concentrations that pose minimal health risks; and

(2) all other LLRW, which present possible longer-term or greater health risks.

For the first category, regulations of the U.S. Nuclear Regulatory Commission (NRC) exempted certain de minimis quantities of radioactive waste materials from required disposal in a licensed LLRW disposal facility, and permitted those small quantities to be diluted and dispersed into the environment. [Title 10 of the Code of Federal Regulations (CFR), Part 20] The second category of waste was required to be isolated from the public and the environment in a licensed, permanent disposal facility. However, no further classifications were defined within this category.

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[1] The "half-life" is the time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Each radionuclide has a unique half-life. Measured half-lives vary from millionths of a second to billions of years.

Prior to 1983, waste was packaged in wooden or cardboard boxes, and some steel drums, to prevent contamination during shipment to disposal sites. The packages were not expected to last for long periods of time after disposal.

The lack of any comprehensive classification system and related technical requirements based on the varied properties of LLRW contributed to many of the disposal problems at the shallow land burial sites described in Appendix 1A of Chapter 1. For example, wastes and waste packaging without adequate stability, as well as inefficient utilization of disposal trench space, allowed subsidence of earthen trench caps, water intrusion, and the subsequent movement of radionuclides within and beyond the disposal trenches. Liquid wastes also were allowed for disposal at that time, and their release into the environment contributed to poor disposal unit performance.

Several waste classification systems were proposed to correct these disposal problems and others at both LLRW and hazardous waste disposal sites. In January, 1983, the NRC promulgated an LLRW classification system as an integral part of its regulations for the land disposal of LLRW.[2] Some of the systems, including the NRC land disposal classification system, are reviewed in this section.

First NRC Study

The NRC began its effort to develop a classification system in the late 1970s by contracting with a number of firms for recommendations that could be developed into such a system. The first phase of the NRC project focused on three actions for handling radioactive waste:

(1) discharging LLRW directly to the environment;

(2) isolating the waste for a specific period of time in a manner that controlled the releases of radioactivity; and

(3) confining the waste so that harmful releases of radioactivity and intrusion by unknowing individuals would be unlikely.

In a report for the NRC published in 1979, the Ford, Bacon and Davis Utah consulting firm (Ford) proposed a classification system "...to classify waste according to the minimum requirements for its safe disposal," not to classify disposal facilities, nor to classify for the purposes of estimating "all radiological environmental impacts from handling wastes or storing wastes in the facilities."[3] This report recommended the use of waste disposal concentration guides as the basis for dividing wastes into separate categories, and determining the proper course of disposal action.

The methodology used in this early classification proposal was as follows:

(1) establish study guidelines and define safe disposal;

(2) determine radiation exposure pathways to individuals and populations;

(3) analyze the movement of radioactive waste via the exposure pathways to determine the concentrations of waste that could potentially expose the public; and

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[2] Nuclear Regulatory Commission. Title 10, Code of Federal Regulations, Part 61.

[3] U.S. Nuclear Regulatory Commission. A Radioactive Waste Disposal Classification System. NUREG/CR-1005, Ford, Bacon and Davis Utah, Inc., September, 1979.

(4) establish classifications using the pathway/exposure analysis.

The Ford study used the following dose-rate guidelines, which were based upon the recommendations of that period from the International Commission on Radiological Protection's "Publication 26:"

(1) Individual exposure to a few individuals should not exceed 500 millirem per year to the whole body[4] or any critical organ.

(2) Individual exposures to many people should not exceed 100 millirem per year to the whole body or any critical organ.

(3) Administrative control (i.e., institutional control[5]) need not last longer than 150 years after the disposal facility ceases to accept waste.

The types of exposure events evaluated in the development of the Ford classification system included such possible events as inhaling dust from digging at a waste site, or ingesting water from a well dug on the site after the institutional control period; consuming food grown in radioactively-contaminated soil; direct exposure to workers or residents from gamma radiation;[6] migration of radioactively-contaminated groundwater to a drinking water source; soil erosion; and waste package corrosion.

The Ford system classified LLRW on each radionuclide's requirements for safe disposal, with larger concentrations of waste requiring stricter facility standards. Five classes of waste were proposed, from Class "E" requiring no administrative control, to Class "A" wastes which must be disposed of in facilities "providing a high degree of isolation."

The five Ford classes, all of which assumed some form of waste burial, were:

- Class E: no administrative controls; waste suitable for sanitary landfill or construction "fill;"
- Class D: some administrative controls with waste buried in shallow land facilities;
- Class C: no administrative controls after disposal operation because the waste is proposed to be buried at an "intermediate depth" (10 meters or deeper);
- Class B: administrative controls for 150 years with waste buried at an intermediate depth; and
- Class A: all wastes with greater concentrations than Class B should be placed in "geologic isolation" (deep disposal).

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[4] "Whole body" dose is to be interpreted to mean "effective dose equivalent" wherever it appears in this Plan. The former term is used in many regulations and documents cited herein, and is retained in the text for consistency with these documents. The latter term represents recent changes in expressing dose.

[5] "Institutional control" is the period following site closure when a program of site monitoring, physical surveillance, and custodial care is conducted.

[6] "Gamma radiation" is short-wave length electromagnetic radiation, which originates from within the nucleus of the atom. Gamma rays are best stopped or shielded by dense materials such as concrete, steel, lead, or uranium.

Department of Energy Recommendations

The U.S. Department of Energy (DOE) proposed a different system of classification. In a report written in 1981, it identified five alternatives for LLRW classification:

(1) maintain the status quo of no comprehensive classification system;

(2) classify all LLRW as one category requiring the same set of standards in packaging, transportation, and disposal;

(3) classify LLRW by the source of generation;

(4) classify LLRW by its radiological hazard; and

(5) classify LLRW by "total hazard to the biosphere."

The DOE recommended that alternative (5) "provides the best assessment of the environmental protection that is needed."[7] The report further explains the total hazard approach:

> "This classification system would separate wastes by total hazard to the biosphere. For example, polychlorinated biphenyls used in transformers at the National Accelerator Laboratory in Illinois have become radioactive by forming Carbon-14. These are now considered as radioactive wastes, although their chemical hazard is greater. The same reasoning would apply to the carcasses and organs of laboratory animals and spontaneously combustible chemicals, whose environmental hazards stem primarily from the biological or physical properties rather than radioactivity. The form of the waste (solid or liquid) is also related to hazard and could be factored into a classification system.
>
> "A clearly defined classification system based on total hazard could be used by all waste generators, transporters, and site operators. The system would delineate the treatment and disposal options for each type of waste. It could be based on the concentration and the half-life of radioactivity, form, physical and biological properties. The categories of waste thus established would correspond to the ultimate disposal technique....It should be sufficiently flexible to accommodate new treatment and disposal methods and to encourage the use of better waste forms. The recommended system need not be complex, and it should result in better waste management."

Consistent with this recommendation that a classification system be based upon both radiological and chemical hazard, in 1982 DOE proposed a methodology for classifying LLRW by total hazard. The suggested method was based upon the concept of a "geological hazard index" introduced by Smith, Cohen, and McKone,[8] and proposed a way to measure the total waste hazard by adding up the "hazard index" of each radiotoxic or chemically toxic material in the waste.

The proposed DOE classification methodology also suggested developing weighting factors for

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[7] U.S. Department of Energy. Managing Low-Level Radioactive Wastes: A Proposed Approach. DOE/LLW-9, National Low-Level Radioactive Waste Management Program, Idaho Falls, ID, April, 1983 (manuscript completed, December, 1981).

[8] Smith, C.F., Cohen, J.J., and McKone, T.E. A Hazard Index for Underground Toxic Material. UCRL-52889, 1980.

various waste characteristics, such as concentration, persistence in the environment, waste form and container, and chemical and biological properties.

Work was never completed to develop a total hazard system index for every radioactive material, and there are no current plans for DOE to do so. Instead, DOE is following a waste management program that essentially complies with the NRC and U.S. Environmental Protection Agency (EPA) regulations and classification systems for the disposal of LLRW and hazardous wastes, respectively.

7.3 NRC's LLRW Disposal Classification System

In 1983, the NRC established an LLRW classification system as part of its regulations for LLRW disposal. [10 CFR Part 61] This classification system is specific to land disposal of LLRW, and may not have applicability for other purposes. The system primarily is based upon the radiological hazards of LLRW, but additional technical requirements of the regulations address other hazards in more general terms.

The classification system is one of three sets of technical requirements specified in Subparts C and D of 10 CFR 61. In developing Part 61, NRC first established general technical requirements in terms of performance objectives, and then derived more specific technical requirements to help ensure that the performance objectives would be met. In general terms, the performance criteria specified are as follows:

(1) **limited dose to any member of the public** from potential releases of radioactivity through various pathways;

(2) **limited dose to an inadvertent intruder** who might occupy the site after institutional control and engage in normal activities such as agriculture and dwelling construction;

(3) **limited dose during operations** to site workers and others;

(4) **long-term stability of the disposal site** to minimize access of water to the waste and to minimize to the extent practicable the need for long-term, active, site maintenance. [10 CFR 61.41- 61.44]

In support of the performance objectives, technical criteria were developed for the four main components that make up an LLRW "system:"

(1) site characteristics;

(2) design and operation;

(3) waste form and packaging; and

(4) institutional controls.

The technical requirements were generally derived from the analysis to determine the performance objectives or from past experience and existing good practices. Most of the technical requirements are related to three key principles that are significant in assuring that the performance objectives are met:

(1) assure long-term stability of the disposal facility and the disposed waste;

(2) minimize the presence of liquids in the waste and the contact of water with waste, both during operations and after the site is closed; and

(3) utilize institutional, engineering, and natural controls to reduce the likelihood and impacts of inadvertent intrusion.

Since the radiological features of the waste were of primary interest, NRC then derived a waste classification system that defined wastes suitable for near-surface disposal in terms of their radiological properties. The waste classification system developed for the Part 61 regulations followed directly from the performance objectives and technical criteria, and therefore is directly dependent upon and linked to them. The classification system can also be viewed as a fifth part of the basic technical requirements that define the NRC's LLRW disposal management system.

The NRC's classification system is based upon the concept of identifying wastes generally acceptable for near-surface disposal, and then further dividing this general category into more specific classes that require different levels of management to satisfy the performance objectives. Four classes of waste were established, based upon NRC's evaluation of the concentrations and half-lives of various radioactive materials. Table 7-1 shows the concentration limits of long-lived and short-lived radionuclides required by the NRC.

These concentration limits were calculated by the NRC on the basis of acceptable dose limits to an individual who inadvertently intruded onto a near-surface burial site after the institutional control period. They are required for <u>all</u> types of disposal technology, not only the near-surface disposal (commonly called "shallow land burial") system assumed by the NRC. Therefore, these radionuclide limits are considered by the NRC to be conservative for any disposal system employing additional protective engineered barriers, such as above-ground vault technology, or other non-shallow land burial methods that would be allowed in Massachusetts.

NRC's four waste classes for disposal purposes are:

Class A wastes are wastes that have no requirements to maintain structural stability but must be segregated from other waste classes at the disposal site. The requirement to segregate this waste is based upon the NRC shallow land burial assumption that the deterioration of these wastes, if mixed with higher activity waste, could lead to "failure of the system and permit water to penetrate the disposal unit and cause problems with the higher activity waste." [Part 61.7(b)(3)] If Class A wastes meet NRC's stability requirements, they may be placed in the same disposal units as Class B and C waste.

Class A wastes are characterized by their low concentrations of long-lived radionuclides and concentrations of short-lived radionuclides that will decay to acceptable levels within an assumed 100-year institutional control period after facility closure.

Class B wastes are the next level of wastes which could represent a potential hazard to an inadvertent intruder without additional protective measures, since they contain higher levels of short-lived and long-lived radionuclides. They must meet NRC's stability requirements so that the waste forms or containers can "maintain gross physical properties and identity, over 300 years," [Part 61.7(b)(3)] thus limiting the potential exposure to an inadvertent intruder.

Class C wastes are wastes that, due to their greater concentrations of long-lived or short-lived radionuclides, have to meet waste form requirements to ensure stability, and must be disposed of in a way to protect the inadvertent intruder for a longer time. These wastes must meet the stability requirements for form or container (300 years) and must be "disposed of so that the top of the waste is a minimum of five meters below the top surface of the cover (of the disposal unit) or must be disposed of with intruder barriers

Table 7-1
NRC Radionuclide Limits

Chart 1
Long-Lived Radionuclide Limits

Radionuclide	Ci/m^3	Radionuclide	nCi/g
Carbon-14	8	TRU(half-life > 5 yr)	100
Carbon-14*	80	Plutonium-241	3,500
Nickel-59*	220	Curium-242	20,000
Niobium-94*	0.2		
Technetium-99	3		
Iodine-129	0.08		

Chart 2
Short-Lived Radionuclide Limits

Class A Limits		Class B Limits		Class C Limits	
Radionuclide	Ci/m^3	Radionuclide	Ci/m^3	Radionuclide	Ci/m^3
half-life ≤ 5 yr	700	Nickel-63	70	Nickel-63	700
Hydrogen-3	40	Nickel-63*	700	Nickel-63*	7,000
Cobalt-60	700	Strontium-90	150	Strontium-90	7,000
Nickel-63	3.5	Cesium-137	44	Cesium-137	4,600
Nickel-63*	35				
Strontium-90	0.04				
Cesium-137	1				

Ci/m^3 = curies per cubic meter; Nci/g = nanocuries (i.e., one billionth of a curie) per gram
* In activated metal
1 If the concentration of the waste exceeds the value in Chart 1 or the Class C limits in Chart 2, the waste is Greater than Class C and is the responsibility of the federal government.
2 The class of waste which contains mixtures of radionuclides listed in the two charts is determined by NRC's "sum of fractions rule." [10 CFR 61.55(a)(7)]
3 If the waste does not contain any radionuclides listed in either chart, it is Class A.

Source: U.S. Nuclear Regulatory Commission. Title 10, Code of Federal Regulations, Part 61. Washington, DC, 1990.

that are designed to protect against an inadvertent intrusion for at least 500 years." [Part 61.52(a)(2)]

Greater than Class C (GTCC) wastes are wastes with concentrations of radioactive isotopes that generally make them unacceptable for near-surface disposal. GTCC wastes continue to be the responsibility of the federal government, and are generally required to be disposed of in a "geologic repository." Proposals to dispose of GTCC waste in an LLRW facility must be approved by the NRC.

As previously noted, the NRC classification system represents one component of a set of requirements that comprise the complete disposal management system intended to assure the safe, long-

term disposal of LLRW in a land disposal facility. The classification system itself does not assure proper waste management, but provides a mechanism to limit, characterize, and categorize LLRW so that it may be managed in the proper way at the disposal facility. Together with the implementation of the other technical, operational, and institutional requirements set forth in the regulations, safe long-term disposal can be provided.

Although the other components of the NRC "systems" approach to LLRW disposal are not part of the "classification" system, as such, it is instructive to review the closely-related technical requirements for waste form and packaging specified in Part 61. These criteria not only are important to convenience and safety in waste handling and to overall facility performance, but also indirectly reflect the inclusion of a "total hazard" approach in managing LLRW.

The NRC technical requirements for waste characteristics include the following specifications:

(1) No cardboard or fiberboard boxes may be used as disposal packaging.

(2) Liquid waste must be solidified or packaged in material which will absorb twice its volume.

(3) No solid waste shall contain more than 1% "free standing and noncorrosive" liquid.

(4) Waste cannot readily detonate, explosively decompose, or react at normal pressures and temperatures, or with water.

(5) Waste cannot contain or produce quantities of toxic gases, vapors, or fumes harmful to transporters, handlers, or disposal workers (except the next condition).

(6) Waste in gaseous form must be kept in containers at a pressure not exceeding 1.5 atmospheres at 20 degrees Centigrade, and the total activity of gaseous waste cannot be greater than 100 curies per package.

(7) Waste must be treated and packaged so as not be pyrophoric.

(8) Waste that contains toxic chemical, biological, pathogenic, or infectious material must be treated to reduce "to the maximum extent practicable" these potential hazards.

In addition to the above list of requirements, all "stable" Class A waste, and all Class B and C waste must meet the additional requirements in Part 61.56(b):

(1) Waste must have structural stability either through the waste form itself, or by placing the waste in a disposal container or additional structures at the disposal site that provide stability.

(2) Liquid waste must meet the requirements of (2) and (3) above, and if treated to a stable form (rather than using containers to assure stability), its liquid volume may not exceed 0.5%.

(3) Void spaces within the waste and between the waste and its package must be reduced to the extent practicable.

Any LLRW which contains, or exhibits the characteristics of, hazardous chemicals as well as radiological components is called "mixed waste." Disposal of mixed waste must satisfy both NRC requirements and the hazardous waste disposal regulations of EPA and the Massachusetts Department of Environmental Protection (DEP). The hazardous waste classification system and related requirements are briefly discussed below; a detailed discussion of mixed waste is contained in Chapter 8.

7.4 The EPA Hazardous Waste Classification System

Hazardous waste and mixed waste are regulated by EPA under the authority of the Resource Conservation and Recovery Act (RCRA) of 1976 and its amendments. Hazardous waste (and the hazardous components of mixed waste) are defined by either being "listed" by the EPA in its regulations [40 CFR 261, Subpart D], or by exhibiting any of four "characteristics" pursuant to 40 CFR 261, Subpart C.[9]

Wastes are considered hazardous if they exhibit any of the following characteristics:

(1) ignitability, (3) reactivity, or

(2) corrosivity, (4) EP toxicity.[10]

"Listed" wastes have one or more of the following qualities:

(1) ignitable, (4) EP toxic,

(2) corrosive, (5) acute hazardous, or

(3) reactive, (6) toxic.

Hazardous wastes have been assigned specific codes for identification purposes as part of EPA's land disposal waste classification system.

Because mixed waste is regulated under both the NRC (Atomic Energy Act of 1954 and amendments) and EPA (RCRA and amendments), the classification of mixed waste for disposal purposes essentially comprises a "total hazard" system encompassing data collection on both radiological hazards and toxic chemical hazards. However, mixed waste constitutes an extremely small percentage of the LLRW stream, and no other LLRW segments are classified in this manner. In addition, no LLRW (including mixed waste) is classified in terms of hazards relating to management by either storage or treatment.

7.5 Recommendations for a "Total Hazard" Classification System

A composite "total hazard" system that encompasses complete LLRW management (i.e., generation, storage, treatment, and disposal) is not currently available at the federal level for addressing all of the potential hazards associated with LLRW and mixed waste. However, a total hazard classification mechanism, for land disposal purposes, is effectively embodied in the separate state, NRC, and EPA regulations governing LLRW disposal. These regulations provide for classification and controlled LLRW disposal based on total hazard through the following mechanisms:

(1) a radiological classification system in NRC regulations based on radiological toxicity, half-life,

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[9] EPA has delegated what it calls "base-RCRA authority" to Massachusetts and other states to regulate hazardous waste. The Massachusetts program is run by DEP pursuant to the authority of Massachusetts General Laws c.21C, the State's Hazardous Waste Management Act and its regulations, Title 310 Code of Massachusetts Regulations (CMR) Part 30.

[10] These characteristics are described in detail in Chapter 8.

and other factors;

(2) technical requirements specified by NRC for waste form, including those on physical, chemical, and biological characteristics noted above;

(3) a hazardous classification system in EPA/DEP regulations based on several characteristics that define chemical hazard;

(4) land disposal restrictions for hazardous (and mixed) wastes not properly treated prior to disposal;

(5) treatment standards or requirements that reduce hazardous characteristics to a level suitable for land disposal; and

(6) facility siting and design requirements consistent with classification, treatment, and other technical requirements specified.

Existing waste classification systems thus represent key elements in more broadly defined regulatory schemes. These management systems not only depend on comprehensive facility siting, design, and performance criteria, but also on classifying and restricting wastes based on toxicity, concentration, quantity, physical form, and other chemical characteristics.

Moreover, the performance of a disposal facility is ensured through various institutional controls such as operator qualification, financial assurances, operating requirements, closure requirements, post-closure institutional control, and environmental monitoring programs.

In constructing a waste classification system for new regulatory programs, it is necessary to consider the system's relationship to the other components of the overall management system to which it applies. The development of a classification system for managing LLRW in Massachusetts is described below with respect to the needs of the Commonwealth as defined in Massachusetts General Laws c.111H (Chapter 111H), the Low-Level Radioactive Waste Management Act.

Massachusetts Classification System

The drafters of Chapter 111H wanted to ensure that a waste classification system could be applicable to all LLRW management activities, including the generation of the waste, its storage, treatment (including waste minimization), and disposal. The law's framers, and the Legislature that adopted it, wanted to ensure that the principles embodied in the NRC and EPA classification requirements for disposal could be utilized by the Commonwealth in these other areas of LLRW management as well.

Because Chapter 111H includes a prohibition against shallow land burial, including any land disposal method "that relies on the site's natural characteristics as the primary barrier" for waste isolation [Chapter 111H, section 1], the law's drafters wanted to ensure that Massachusetts required a classification system which exceeded the requirements of the NRC's land disposal system, in that it provided a "total hazard" system for disposal of LLRW in the Commonwealth.

The Massachusetts law requires a classification method that extends beyond radiologic hazard to the "total hazard" concept discussed in this section.

Section 12(b)(1) of Chapter 111H requires that the waste classification system include the following elements:

(1) it must be based primarily on radiological toxicity and radioactive half-life;

(2) the principal radionuclides present in the waste and their concentrations;

(3) the specific activity of the waste;

(4) the chemical and biological toxicity and form (liquid or solid) of the waste;

(5) the chemical reactivity of the waste;

(6) waste volume; and

(7) other characteristics as determined by the Management Board.

The statute explicitly requires that these elements be factored into a classification system which is "compatible with federal requirements." The provision for considering "other characteristics" (number (7) above), is intended to enable the Management Board to determine which classes of LLRW may be stored for decay, which classes will require disposal, and which classes will require "special management procedures in order to facilitate the safe and timely closure, post-closure observation and maintenance, and institutional control of the facility accepting such LLRW." [Chapter 111H, section 12(b)(1)]

The Massachusetts classification system established by the Low-Level Radioactive Waste Management Board incorporates NRC and EPA requirements into a **total hazard, total management**-based system. Its purpose is to provide data and information to allow the Management Board to make "management" decisions.

The data to be derived from a classification system for Massachusetts will be used for a number of purposes. They will assist in tracking waste generation and in the siting, design, performance assessment,[11] licensing, closure, monitoring, and possible remediation of future storage, treatment, or disposal facilities. They may also be used to make assessments and decisions on other waste management needs, such as the need for additional waste minimization and other waste treatment steps. Potential data needs identified at this time are listed in Table 7-2. Detailed waste characterization data will be required for all of these purposes.

The classification system established here provides a framework for organizing the data of interest. It provides a mechanism for compiling and analyzing the data and classifying waste streams in a variety of ways for various program needs. The classification system, then, consists of several parts:

(1) A survey, or data acquisition tool, to allow detailed characterization of each waste stream;

(2) An inventory, or data compilation tool;

(3) A codification system to allow categorization, classification, and data sorting;

(4) A codification system to allow identification, management, and disposal consistent with other federal and state regulations (e.g., NRC, EPA, DEP);

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[11] "Performance assessment" is a systematic analysis of the potential risks to the public and the environment posed by waste management systems, and a comparison of those risks to established safety requirements.

Table 7-2 LLRW Classification Data Requirements	
Waste Stream Data Requirement	**Purpose or Data Use**
1. Physical description	process options, stability, performance, retrievability
2. Major chemicals	performance assessment, mobility, materials compatibility, EPA/DEP hazard, retrievability
3. Solidified/matrix	process requirement, performance/stability, process options, retrievability
4. Density	shielding/dose assessment, performance, retrievability
5. Weight	density/handling/design, retrievability
6. Volume of waste in package	processing options, total volume, classification, retrievability
7. Chelating agents: a. type	groundwater transport rates/performance, retrievability
b. amount	process options, segregation, retrievability
8. No. of packages of a particular type	facility design, performance, total volume, retrievability
9. Container description a. size c. thickness b. material d. weight	design, performance, handling processing, shielding, dose rates, retriev-ability
10. Radiation level distribution	handling, processing, dose assessment, design, retrievability
11. Isotopic content/quantities	performance/dose assessment, classification, total activity, retrievability
12. Disposal classification	design, performance, operations, retrievability
13. Biological content	processing options, stability, performance, hazard potential, retrievability
14. Treatment performed	further process options or stability requirements, retrievability
15. Disposal site, storage site, broker, processor utilized	tracking, inventory control, consistency in data reporting
Source: Massachusetts Low-Level Radioactive Waste Management Board, 1991.	

(5) A data manipulation and analytic tool to process and compile data by any characteristics of interest and for any need; and

(6) A classification and tracking (manifest) system to allow operation, monitoring, and remediation, if necessary, at potential storage, treatment, or disposal facilities.

The most effective way of managing the large amount of information required by such a system is through the use of an electronic (computerized) inventory program. This tool is a key element of the classification system. Each waste stream is entered into a spreadsheet/data base and is characterized by several identifying features, from waste producer and location, to radioisotopic signature. Alphanumeric codes are assigned to parameters of particular interest to allow identification, compilation, sorting, and summarizing data for the many purposes previously noted.

Because of the large number of possible combinations of these waste characteristics, it is not practical to predetermine an alphanumeric classification code for every possible waste. However, a

combination of the characteristic codes assigned to each waste stream in the spreadsheet database can be assembled to "classify" the waste stream or container for any management purpose.

For example, if the Management Board (or member of the public) wishes to evaluate the treatment performed on LLRW containing biological material, an analysis of characteristic codes relating to "biological content," "treatment," "processor utilized," and others allows the Board to classify the waste of interest for various management purposes.

To a large extent, the mechanism for data collection for the electronic data base is recommended to be the annual survey of all radioactive materials users, required by section 7 of Chapter 111H. This survey, called the "LLRW Classification Survey," has been formatted by the Management Board to identify distinct waste streams and allow direct input of data into the electronic spreadsheet/database.

The operation, closure, and monitoring of any LLRW management facility will require data and data management capability similar to that described for this classification system. A waste "manifest" system would be established requiring waste characterization data for each package of waste shipped to such a facility. The waste manifest and facility database system will be a logical extension of the waste classification survey and classification database system described here.

The classification system will allow identification of any waste stream (i.e., any number of packages with similar characteristics), or ultimately, any individual package of LLRW in terms of the characteristics specified in Chapter 111H.

To retain compatibility with current practice, programs of other states and compacts, and the regulations of the NRC, EPA, and DEP, all waste potentially suitable for land disposal is classified consistent with the federal regulations and guidelines for disposal of LLRW and hazardous waste.[12] In addition, the EPA classification system for treatment, storage, and land disposal of the hazardous components of LLRW is incorporated as a part of the overall classification system.

The Massachusetts LLRW disposal classification system is illustrated in Table 7-3, and is incorporated as part of the Commonwealth's overall LLRW classification system.

The following parameters will be collected and evaluated as part of the classification of LLRW generated in Massachusetts, although not all would apply to a given waste type:

(1) generator identification;

(2) location of waste generated -- city/town;

(3) waste type;

(4) radioactivity -- total activity, radioisotopic content of waste stream, specific activity, millicuries or millicuries/container for each radionuclide;

(5) container radiation levels, if applicable -- range of levels and typical level for the waste stream;

(6) treatment performed on site, volume and activity reduction achieved;

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[12] Massachusetts law does not include GTCC waste in the State's definition of LLRW. GTCC waste is monitored for tracking purposes, however.

Table 7-3 Classification for Licensed LLRW Disposal	
Disposal Class	**Description**
AU	Class A unstable LLRW.
AS	Stabilized Class A LLRW.
B	Class B LLRW per NRC.
C	Class C per NRC.
GTCC	Greater-than-Class-C.[1]
AU-H	Class A unstable LLRW with treated RCRA/DEP hazardous waste components.
AS-H	Stabilized Class A LLRW with treated RCRA/DEP hazardous waste components.
B-H	Class B LLRW with treated RCRA/DEP hazardous waste components.
C-H	Class C LLRW with treated RCRA/DEP hazardous waste components.
GTCC-H	Greater-than-Class-C LLRW with treated RCRA/DEP hazardous waste components.[1]

[1] GTCC waste is the responsibility of the federal government. GTCC is classified here for tracking purposes only.

Source: Massachusetts Low-Level Radioactive Waste Management Board, 1991.

(7) physical matrix, if applicable -- solidification or sorption media;

(8) EPA/DEP hazard code(s), if applicable -- before and after treatment and EPA/DEP treatment employed;

(9) chelating agents[13] -- type and amounts greater than 1%;

(10) type of containers and number of each type used each year for storage or disposal -- description, dimensions, full weight, disposal volume;

(11) disposal class -- Massachusetts/NRC compatible classification;

(12) disposal site used;

(13) storage site used;

(14) total volume/year;

(15) volume and activity shipped to broker or processor;

(16) treatment used by broker or processor;

[13] "Chelating agents" are certain organic compounds capable of forming (multiple) coordinate bonds with metals through two or more atoms of the organic compound, typically resulting in enhanced thermodynamic stability in solution and greatly altered behavior of the metal ions. Chelating agents are used to reduce or eliminate metals from radioactively-contaminated solutions.

(17) volume and activity delivered from broker or processor for storage or disposal;

(18) broker and processor identification;

(19) volume and activity held in storage for future disposal;

(20) storage location -- city/town;

(21) treatment of stored waste planned prior to disposal;

(22) expected volume, activity, and disposal class of stored waste after treatment;

(23) expected shipment date of stored waste;

(24) total volume and activity of waste stream held for decay to level not requiring licensed radioactive waste treatment or land disposal;

(25) identification of disposal techniques used other than storage for decay or licensed off-site disposal -- volume and activity so managed; and

(26) termination of production of waste stream or decommissioning waste streams -- date expected, type of waste, volume, activity, percentage of major radionuclides.

Complete classification of a waste stream is possible by using the applicable information available from this system. The many parameters with which a waste stream may be defined are more completely illustrated in the "LLRW Classification Survey" form, instructions, and code listing distributed annually by the Management Board to all radioactive materials users in the Commonwealth.

7.6 Chapter References

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Chapter 8: The Mixed Waste Regulatory Dilemma

8.1 Introduction

Until 1976, all regulation of low-level radioactive waste (LLRW) was under the purview of the U.S. Nuclear Regulatory Commission (NRC), pursuant to the Atomic Energy Act (AEA) of 1954, as amended. However, in 1976, Congress passed the Resource Conservation and Recovery Act (RCRA), unintentionally creating a system of dual regulation of the very small portion of LLRW that is mixed with materials listed as hazardous waste, or otherwise exhibits hazardous properties.

Over 15 years have passed since that dual regulatory system was established, and the two chief federal regulatory authorities for "mixed waste" -- the NRC and the U.S. Environmental Protection Agency (EPA) -- are still working to develop all the joint guidance policies necessary to fulfill their shared regulatory responsibilities.

The lack of uniform guidance from these two agencies has caused serious repercussions to those who produce mixed waste, as well as to those in federal and state regulatory agencies charged with enforcing what, in some cases, is contradictory, duplicative, and costly public policy.

Because the federal mandate assigning responsibility for LLRW management and disposal took effect on Jan. 1, 1993,[1] state officials, including the Low-Level Radioactive Waste Management Board in Massachusetts, have been aggressively pressing responsible federal agencies for decisions that will resolve the contradictions and duplications in the existing regulatory system.

This chapter examines the dual regulatory responsibilities of the EPA and NRC; procedures for identifying mixed waste; the general categories of mixed waste streams produced in Massachusetts; and the regulation of mixed waste on the state level; it concludes with recommendations to improve mixed waste management.

8.2 Defining Mixed Waste

Mixed wastes are those that exhibit both hazardous and radioactive properties. In general, at the federal level they are subject to the jurisdiction of EPA, which regulates hazardous wastes under RCRA, and of the NRC, which regulates radioactive materials under the AEA. They are a very small part of the commercial LLRW stream, as shown in Figure 8-A, which uses data from the most recent national survey of commercial mixed waste. Mixed wastes are estimated to comprise between 3-5% of the total commercial

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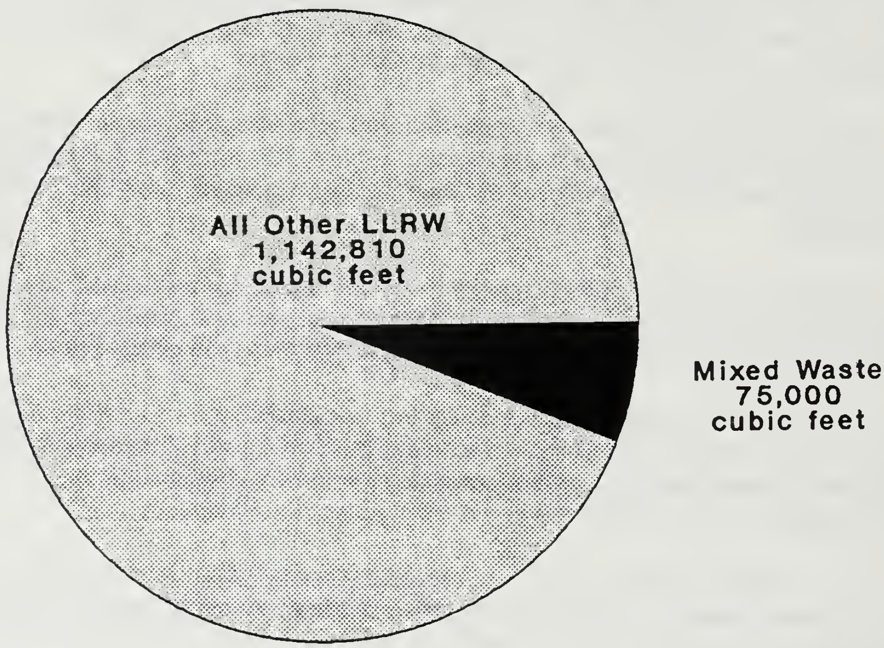
[1] Details of this and other federal requirements assigned to all 50 states are discussed in Chapter 1 of this volume.

(i.e., non-federal government, non-defense LLRW) waste stream, requiring disposal in licensed LLRW disposal facilities. In 1990, a total of 1.1 million cubic feet of non-mixed waste was shipped for disposal. The non-mixed commercial LLRW disposed of was 1.4 million cubic feet in 1991, and 1.7 million cubic feet in 1992. Based on estimates provided for the 1990 national profile on commercial mixed waste, the estimate of 3-5% continues to be accurate.

By comparison, non-radioactive, hazardous waste generation rates are estimated to be in the billions of cubic feet per year. However, the costs of regulating mixed waste comprise a significant percentage of the budgets of the two federal agencies, and their counterpart state agencies, as well as the costs to mixed waste generators and the Commonwealth for the management of this waste.

Figure 8-A
Percentage of Total Commercial Mixed Waste as Compared to Total, Commercial Non-Mixed LLRW Shipped for Disposal[1] in 1990



[1] According to results from the most recent national survey of mixed waste generators, about 140,000 cubic feet of mixed waste is estimated to have been produced in 1990. Of that amount, 65,000 cubic feet was eliminated through incineration, and 53% (75,000 cubic feet) could not be treated or disposed of. For the purpose of illustrating this small percentage of mixed waste, that had no disposal options, this pie chart assumes that all of the 75,000 cubic feet in storage for lack of treatment or disposal would have been sent to a licensed LLRW disposal facility, had one been available in 1990. It also assumes that no treatment was able to reduce the 75,000 cubic feet volume. Given this situation, the percentage of mixed waste to non-mixed LLRW (shown as "all other LLRW" in Figure 8-A) is extremely small.

Source: Oak Ridge National Laboratory. National Profile on Commercially Generated Low-Level Radioactive Mixed Waste. NUREG/CR-5938 ORNL-6731. Oak Ridge, TN: December, 1992.

The issue of EPA's authority to regulate mixed waste has stirred controversy for a decade, because of the confusion caused by language in RCRA. EPA views mixed waste as a small subset of toxic, chemical

"hazardous waste"[2] which in turn is a subset of "solid waste." Because the definition of "solid waste" excludes most radioactive materials, it was originally thought that any hazardous wastes that were contaminated with radioactive materials were not subject to EPA regulation.[3]

However, in 1986, EPA asserted its jurisdiction over the **hazardous** components of mixed waste under its regulations, 40 Code of Federal Regulations (CFR) Parts 124 and Parts 260 through 270. While acknowledging that the NRC had responsibility to regulate the **radioactively-contaminated** constituents, the EPA argued that the exemption in RCRA applied only to the radioactive materials themselves, not to any hazardous waste portions of mixed waste.[4]

A second confusion over RCRA authority involved disagreements among EPA, NRC and the U.S. Department of Energy (DOE) over the term "byproduct material" and what pure byproduct material wastes would be exempt from RCRA.

In 1987, EPA and NRC agreed on a regulatory framework for mixed waste, and issued a joint interpretation, defining "mixed waste" as:

> "... waste that satisfies the definition of low-level radioactive waste...in the Low-Level Radioactive Waste Policy Amendments Act of 1985 and contains hazardous waste that either (1) is listed as a hazardous waste in Subpart D of 40 CFR 261 or (2) causes the low-level radioactive waste to exhibit any of the hazardous waste characteristics identified in Subpart C of 40 CFR Part 261."

Hazardous Waste "Characteristics" and "Lists"

The terms "characteristic" and "listed" hazardous wastes are mentioned frequently in this chapter, and refer to the way in which EPA developed its regulatory framework to identify those solid wastes that must be managed as hazardous wastes. The framework specifies that a solid waste is a hazardous waste if it is not explicitly excluded from regulation, and if it meets any of the following conditions:

(1) it exhibits any of the "characteristics" of ignitability, corrosivity, reactivity, or toxicity, as identified in Subpart C of 40 CFR 261, or

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2 "Hazardous waste" is defined in RCRA as a "solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may: (1) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness or (2) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed." [42 USC 6901, Section 1004(5)]

3 RCRA defines "solid waste" as "...any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities," but excludes ..."source, special nuclear, or byproduct material as defined by the Atomic Energy Act of 1954, as amended." [42 USC 6901, Section 1004(27)]

4 As is discussed in detail in Section 8.4, the Massachusetts Department of Environmental Protection (DEP) is not "RCRA authorized" to regulate mixed waste. However, DEP can regulate this waste pursuant to the State's hazardous waste law, Massachusetts General Laws c.21C, which gives Massachusetts authority to control mixed waste independent of RCRA.

(2) it has been named as a hazardous waste on "lists" included in Subpart D of 40 CFR 261.31-261.33 of the EPA regulations.

"Characteristic" **hazardous waste**, therefore, is waste that exhibits:

- Ignitability: a liquid with a flash point less than 140°F (except aqueous solutions containing less than 24% alcohol); a non-liquid capable of spontaneous and sustained combustion; an ignitable compressed gas pursuant to U.S. Department of Transportation (DOT) regulations; an oxidizer per DOT regulations.

- Corrosivity: an aqueous material with a Ph less than or equal to 2 or equal to or greater than 12.5; a liquid that corrodes steel at a rate greater than one-quarter Inch per year at 130°F.

- Reactivity: a waste which is normally unstable and reacts violently without detonating; reacts violently with water; forms an explosive material with water; generates toxic gases, vapors or fumes when mixed with water; contains cyanide or sulfide and generates toxic gases, vapors or fumes at a Ph of between 2 and 12.5; capable of detonation if heated under confinement or at standard temperature and pressure; listed by DOT as a Class A or B explosive.[5]

- Toxicity: a waste which is likely to leach hazardous concentrations into groundwater, if the waste is improperly managed.[6]

"Listed" **hazardous waste** is waste, mixtures of hazardous and solid wastes, or residues derived from a listed waste that is named on one of three EPA lists:

(1) Nonspecific source wastes: generic wastes, commonly produced by manufacturing and industrial processes.

(2) Specific source wastes: wastes from specifically-identified industries such as chemical manufacturing, wood preserving, etc.

(3) Commercial chemical products: specific commercial chemical products and manufacturing chemical intermediates such as chloroform, creosote, sulfuric acid, and pesticides.

Chemical hazards may be found in, or in combination with, LLRW, high-level radioactive waste, transuranic waste, or spent nuclear fuel. However, only radioactive waste at concentrations equivalent to LLRW that exhibits hazardous properties or is combined with materials listed as hazardous waste Is generally

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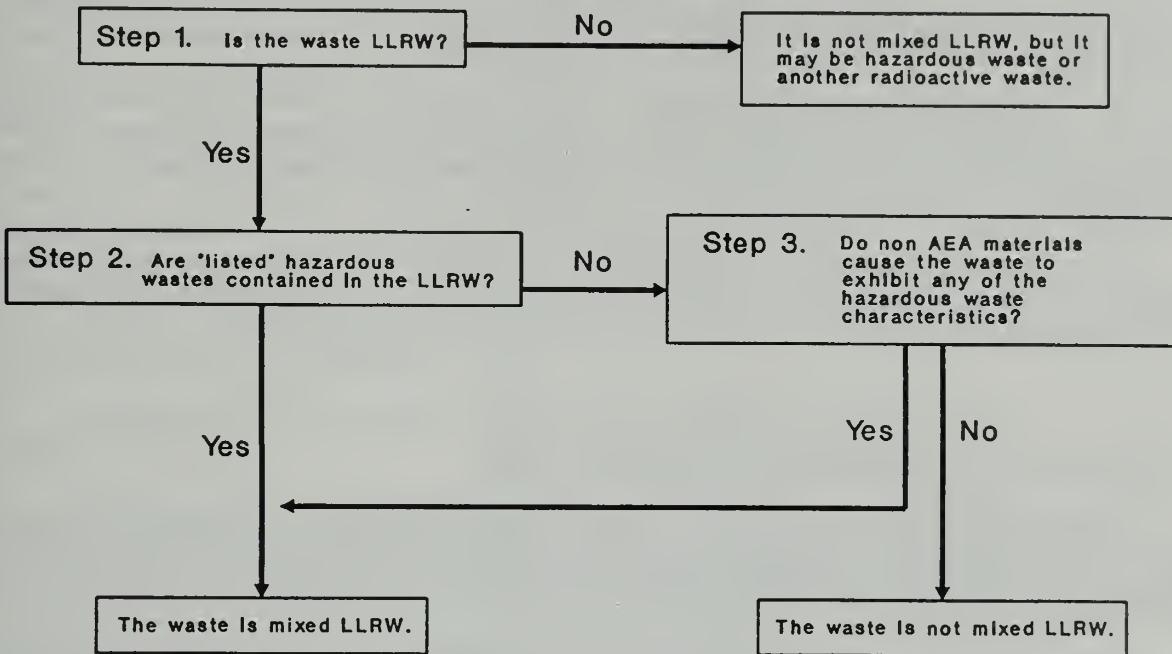
[5] The "Class A and B" explosive classes are not the same as "Class A" and "Class B" radioactive wastes.

[6] To ascertain toxicity, EPA originally used an "extraction procedure" (EP) toxicity test, in which hazardous constituents were extracted from the waste and analyzed to determine if they Included certain toxic contaminants (such as arsenic, cadmium, lead, mercury, etc.) in concentrations which would make the waste hazardous. Because of criticism that the EP toxicity test Inadequately simulated the flow of contaminants In drinking water, In 1990, EPA replaced this test with the Toxicity Characteristic Leaching Procedure (TCLP) test. This test Is used to expose waste material to an acidic environment as a means of predicting which materials In the waste may be released into groundwater. If materials released exceed levels set by the EPA in its TCLP table of 39 inorganic constituents (such as arsenic, cadmium, lead, mercury, 1,2-dichloroethane, 1,4-dichlorobenzene, etc. – 25 more than used for the EP toxicity test), the waste is considered legally hazardous and must be handled as such.

considered "mixed" waste, and the subject of the discussion in this Management Plan.[7]

Figure 8-B
Logic Diagram for Identifying Mixed LLRW



Source: EPA/NRC. "Guidance on the Definition and Identification of Commercial Mixed Low-Level Radioactive and Hazardous Waste." Washington, DC, Oct. 4, 1989.

Identifying Mixed Waste

In October, 1989, EPA and NRC updated their joint guidance on mixed waste to assist all radioactive materials licensees in determining whether they generate mixed waste. The guidance, illustrated in Figure 8-B, is comprised of a three-step methodology:

Step I: Identify LLRW. The generator is encouraged to evaluate the waste by reviewing the definition

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[7] The issue of whether spent nuclear fuel is a mixed waste is still undecided by EPA. However, EPA has decided that mill tailings waste will not be considered a RCRA mixed waste. Mixed waste may also be a mixture of hazardous waste and Naturally Occurring and Accelerator-produced Radioactive materials (NARM) waste. NARM waste is not covered by the LLRW definition in the AEA, nor by RCRA. However, EPA is expected to develop proposed regulations for NARM waste disposal as part of its establishment of LLRW regulations, using the authority of the federal Toxic Substances Control Act of 1976, as amended. A subset of NARM, called NORM (Naturally Occurring Radioactive Material) waste generally consists of large volume, low-radioactivity soils and debris containing radium, uranium, and thorium. Some NORM mixed waste (that which contains less than 2,000 picocuries per gram of total NORM activity) is accepted for disposal at a NORM disposal site in Utah, owned by Envirocare Corporation. Because the federal government has ignored the regulation of NORM waste in the past, many states have adopted standards to regulate this waste. The Massachusetts Department of Public Health (DPH) has authority over NORM pursuant to Massachusetts General Laws c.111, section 5N.

of LLRW. (See Chapter 4) The guidance notes: "If the generator determines that the waste is LLRW, the generator should proceed to step 2. If the determination is negative, then the waste cannot be mixed LLRW because it is not LLRW. However, the waste may be another radioactive or hazardous waste regulated under AEA, RCRA, or both statutes."

Step 2: Identify listed hazardous waste. The generator next determines if the LLRW contains any materials listed as hazardous wastes in Subpart D of 40 CFR Parts 261.31 through 261.33.

Step 3: Identify hazardous characteristics. If the waste does not contain a material "listed" as hazardous waste under the regulations cited in step 2, then the generator must determine whether the LLRW contains materials that exhibit any of the four characteristics described above (i.e., ignitable, corrosive, reactive, or toxic) and identified in Subpart C of 40 CFR Part 261.

If the LLRW contains any listed waste pursuant to step 2, or exhibits any of the hazardous characteristics pursuant to step 3, then the waste is mixed waste and must be managed as such under dual EPA/NRC regulatory control.

8.3 Types and Generators of Mixed Waste

General categories of mixed waste streams are briefly described below. Treatment requirements depend upon the knowledge of the radionuclides in the waste, the physical form of the waste, the NRC LLRW disposal class (i.e. Class A, B, or C), and the chemical form.

1. Liquid scintillation fluids. Scintillation fluids are organic chemical solutions that produce light when bombarded with radiation. Hospitals, universities, biotechnology companies, and other industries use scintillation liquids in various laboratory procedures, including diagnosis of diseases such as cancer and research on Acquired Immune Deficiency Syndrome (AIDS). They constitute the largest volume of mixed waste produced nationwide, as well as in Massachusetts, due to the extensive biomedical and nuclear medicine research conducted in this state.

The predominant radioactive portion of these fluids is usually comprised of Carbon-14 or Hydrogen-3 (tritium). The hazardous component may be xylene, toluene, benzene, or other organic solvents defined as hazardous under RCRA.

Approximately 3,800 cubic feet of mixed waste liquid scintillation fluids were generated in Massachusetts in 1991, and 2,900 cubic feet in 1992, according to data compiled from the annual survey of radioactive materials users conducted by the Low-Level Radioactive Waste Management Board.

There are several ways to manage liquid scintillation fluids, depending upon their content. One of the most frequently-used methods is the utilization of two exemptions contained in federal regulations: one is an NRC regulation regarding de minimis quantities of Carbon-14 and tritium; the second is a RCRA regulation that excludes certain wastes from the "hazardous" definition if they can be burned as fuel.

The NRC regulation, 10 CFR 20.2005, allows scintillation liquids to be disposed of as **hazardous waste** without regard to the radioactive contents, if they contain 0.05 microcuries or less of tritium or Carbon-14 per gram of waste material. Further, if the fluid is not considered an LLRW, the hazardous chemical content can be burned as a "fuel" and the incinerator residue is not regulated as a hazardous waste pursuant to Section 3001(b)(3)(A) of RCRA. If the radioactive content is greater than 0.05 microcuries

per gram, this waste must be treated as a mixed waste.[8]

Another management option Is substitution. The components In liquid scintillation fluids can sometimes to substituted by non-hazardous and non-radioactive materials, such as bio-degradable scintillation liquids Instead of toluene and xylene; and by non-radioactive materials, such as enzymes and fluorescent labeling materials instead of the radioactive tracers. Such substitutions can result In removing scintillation fluids from the mixed waste category, as well as the LLRW and hazardous waste groupings. The replacement of only the non-radioactive materials requlres the fluid to be managed as a hazardous waste; likewise, the substitution of only non-hazardous materials requires the waste to be regulated as an LLRW.

2. Organic chemicals. Other organlc chemicals, such as acetone and methanol, are used In academic and medical research, industrial manufacturing -- such as the production of sealed sources and radiopharmaceuticals -- and in nuclear power plants. This type of chemical is also used to clean and decrease equipment, instruments, and clothing that have become radioactively-contaminated.

A total of 512 cubic feet of this type of mixed waste was reported generated in Massachusetts in 1991, and approximately 800 cubic feet In 1992.

Storage for decay and incineration are typical management strategies for many types of organic chemical mixed waste.

3. Lead Wastes. Radioactive materials licensees use lead for shielding and containers or may produce radioactively-contaminated lead wastes in solutions from the chemical or water removal of radiation from lead surfaces. Most lead containers are recycled or reused, and, therefore, the volume of mixed lead waste is fairly small. In addition, lead shipping containers coated with steel or paint are not currently considered mixed waste if they are decontaminated and reused.

Before disposal as a hazardous waste, the EPA requires radioactive lead solids to be treated by "macroencapsulation" by coating the lead surfaces with plastics or resins in order to reduce the potential for the lead, as oxides, to leach from the surface. Decontamination solutions containing lead can be solidified to reduce their hazardous characteristics below the EPA "toxicity" limit, thereby allowing their disposal as LLRW.

4. Chromate and cadmium wastes. Chromates, cadmium, and other heavy metal mixed wastes are generated primarily at nuclear power facilities, where the chromates are frequently used to reduce corrosion in auxiliary systems. Reactor LLRW that may contain chromates includes ion-exchange resins, evaporator concentrates, and filter media. Those potentially containing cadmium include welding rod stubs, blast grit, and other decontamination materials.

Both forms of mixed waste must be treated prior to disposal In order to fall below the EPA toxicity level. Chromate mixed wastes are generally stored on site until treatment and disposal are available. If necessary, cadmium wastes are solidified and stabilized by the addition of other chemicals, in order to pass the toxicity test so that they can be managed as radioactive waste rather than mixed waste. Contaminated welding rod stubs are also disposed of as LLRW.

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[8] Incinerators that burn spent scintillation fluids as a fuel additive do not currently need an EPA permit. However, EPA may soon require the permitting of such facilities. Much of this waste produced in Massachusetts and other states is treated by Quadrex Corporatlon in Gainesville, Florida, and then is sent to an incinerator In Green Cove Springs, Florida, to be burned as fuel. Waste containing higher radioactivity levels than 0.05 microcuries per gram is processed by the other companies listed in Table 8-4.

Another inorganic chemical mixed waste produced in lesser quantities is mercury, which is used in the manufacture of life science compounds, measuring devices, lamps, and other electronic components; and vacuum line technology (manometer and transfer pumping). Because mercury is a characteristic waste, neither it nor any residual material remaining from treatment can be removed from the hazardous waste category. Therefore, despite treatment, mercury mixed waste will still require disposal as a mixed waste.

5. Chlorinated fluorocarbons. These wastes, better known as "CFCs," are generated during normal maintenance operations at nuclear power plants, in some dry-cleaning operations, and at federal defense and research facilities.

The management of CFC mixed wastes is similar to that described for other organic chemicals in (3), above. Some can also be recycled for re-use. However, due to lack of available treatment and disposal for all CFC mixed wastes, generators of this type are forced to store on site until improved waste treatment and disposal techniques become available. There are no existing treatment techniques available to render CFC wastes non-hazardous. Research into substitution of CFC chemicals and minimization of CFC wastes is on-going.

6. Water-soluble corrosive liquids. These liquid wastes are produced from their use at nuclear power plants during the process of back-flushing ion-exchange resins, and at locations where radioactive waste transportation containers are cleaned for reuse.

Treatment options include neutralization to render the waste non-hazardous, and EPA-permitted sewer discharge if the waste is part of a wastewater treatment operation.

7. Waste oil. Approximately 1.3 billion gallons of non-radioactive waste oil are produced annually in the United States. Waste oil is not considered a hazardous waste by the EPA. However, it is considered a hazardous waste in Massachusetts, since the passage in 1980 of Massachusetts General Laws c.21C, the State's Hazardous Waste Management Act.

Regulations of DEP, which has received EPA authorization for its hazardous waste program, but not for a mixed waste program,[9] explicitly exclude "radioactive waste oil" from the definition of mixed waste. DEP's decision to exclude waste oil followed an analysis and conclusion that existing radiological controls of the NRC provide equivalent protection to public health, safety, and the environment, and that dual regulation in this instance was unnecessary.

Waste oil is a mixed waste if it acquires radioactive material from contact with radioactively-contaminated equipment. Mixed waste oil is produced from oil changes at nuclear power plants, accelerators, academic research reactors, and commercial facilities where machinery is cleaned and maintained.

Unlike mixed CFC wastes, mixed waste oil has a variety of management options. They include solidification, incineration, filtration, and storage.

Before it ceased operation in December, 1992, the commercial LLRW disposal site in Beatty, Nevada, accepted solidified waste oil for disposal, if it was first absorbed or solidified, using materials approved by the State in order to render the toxic characteristics non-hazardous to meet state LLRW

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[9] DEP applied for authorization to regulate mixed wastes in the winter of 1991. The EPA approval process is lengthy, and is expected to take two or more years.

disposal requirements.[10] These requirements dramatically increase the volume of waste oil requiring disposal. The Barnwell disposal site In South Carolina refuses to accept waste oil in any form. However, Barnwell does take oil Incidental to other LLRW (such as residual lubricating oil on metal scrap surfaces), if such oil is combined with an absorbent, and does not exceed 1% by volume of any container.

Filtration Is a popular means of managing mixed waste oil. The oil is filtered through multi-layer paper filters to remove the radioactive particulates, so that the filters can be disposed of as radioactive waste, and the remaining oil can be disposed of as hazardous waste (under the Massachusetts definition).

Mixed Waste Generators

Mixed waste is produced in Massachusetts by all the LLRW generator "types" described in Chapter 4. Average annual mixed waste volumes generated in Massachusetts are shown in Table 8-1. All operating nuclear power plants licensed by the NRC are sources of mixed waste generation, as a result of the hazardous waste produced from routine operation and maintenance activities. The cleaning and replacing of equipment produces paper, cleaning solutions, and cloth contaminated with acetone, trichloroethylene solvents, and CFCs. The so-called "off-line" power plant refueling activities generate contaminated solvents, oil, and welding rod stubs and blast grit, which both contain cadmium.

In addition, the decontamination of tools, equipment, and radioactively-contaminated areas within power plants produce acetones, spent dichlorobenzene, and methanol-contaminated clothing. The analysis of the power plant reactor water to determine radionuclide levels produces spent scintillation fluids containing xylene and toluene, and certain other operational activities produce wastes containing chromates, acids, and sludges that may contain CFCs.

A study published in January, 1990, by an organization representing utilities, conservatively estimated that each nuclear powered plant generates 750 cubic feet of mixed waste annually, after source and volume minimization.[11]

Medical and academic users of radioactive materials also produce mixed waste in research, teaching, experimentation, diagnostic procedures, and therapeutic applications.

Commercial LLRW generators who produce mixed waste as a by-product of their activities, include radiopharmaceutical, sealed source, biotechnology, and Irradiator manufacturers; isotope suppliers; fuel fabrication operations, and LLRW treatment companies. Those licensees who strictly use "sealed sources"[12] In devices Involving measurement, calibration, and Irradiation applications, do not generate mixed waste, since the radioactive material Is sealed and therefore does not come In contact with hazardous waste.

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[10] The Hanford, Washington, disposal site continues to accept solidified or absorbed waste oil from generators within the Northwest and Rocky Mountain compact states.

[11] The study, conducted by the Nuclear Management and Resources Council, identified a level of mixed waste production that differs from the volumes documented In the utility companies' applications to EPA for Part A licenses. The level in the EPA license request averaged 50 cubic feet a year, excluding waste oil. The study concluded that the amount of mixed waste generated at each utility plant depends upon management practices and specific materials used.

[12] A "sealed source" is radioactive material encapsulated In a shell of non-radioactive material, which prevents any radioactive contamination from escaping outside the shell.

Table 8-1
Average Annual Mixed Waste Generation in Massachusetts[1] by Generator Category
(cubic feet)

Production\Disposition	Generator Category: Acad	Comm	Govt	Health	Utility	Total	% of Total
Produced	826.5	1,839.6	326.3	1,222.7	77.1	4,292.1	
Waste Avoidance							
Placed in Storage	58.4	389.3	326.3	86.0	75.0	934.9	21.8
Storage for Decay	25.5	311.5	0.0	111.2	0.0	448.2	10.4
Incineration (in State)	0.0	115.0	0.0	0.0	0.0	117.0	2.7
Return to Manufacturer\Supplier	0.0	0.0	0.0	5.0	0.0	0.0	0.0
Recycle\Recover	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sewer Release	0.0	120.0	0.0	5.0	0.0	125.0	[illegible].9
Atmospheric Release	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	83.9	935.8	326.3	204.2	75.0	1,625.1	37.9
Broker\Processor Treatment							
Shipped to:	742.6	903.8	0.0	1,018.6	2.1	2,667.0	N/A
Shipped from:	20.1	19.3	0.0	0.0	0.0	39.3	N/A
Volume Eliminated	722.5	884.6	0.0	1,018.6	2.1	2,627.7	61.2
Shipment for Disposal	20.1	19.3	0.0	0.0	0.0	39.3	0.9

[1] Data on 1991 and 1992 mixed waste generation were used to develop this table. NRC regulations enable radioactive materials licensees to designate "materials" as "waste" when it is ready to be shipped for disposal. While in storage, prior to shipment, therefore, some generators call this material "radioactive material;" other generators call it "LLRW." This phenomenon may explain why certain generator categories - especially the utilities - do not report the generation of mixed waste. Another explanation may relate to the prohibition by the EPA/DEP on storing mixed waste on site. Section 8.4 discusses the regulatory confusion of existing rules, which has led some generators to their hesitancy to report any mixed waste activity.

Source: Massachusetts Low-Level Radioactive Waste Management Board. 1991 and 1992 Massachusetts Low-Level Radioactive Waste Survey Reports. Boston, MA, November, 1992 and October, 1993.

Table 8-2 shows the potential mixed waste streams by generator type and waste category.

Until the time a national profile was developed on mixed waste from an NRC/EPA-sponsored survey, little information was known about the exact volume and categories of mixed waste produced nationally by non-federal government generators. Survey results were compiled by Oak Ridge National Laboratory, who collected mixed waste generation data from 1,106 mixed waste generators around the country, representing the five major radioactive materials user categories, namely academic, commercial, medical, nuclear utility, and NRC-/Agreement State-licensed government entities. The raw data was then weighted to represent the correct percentages of generators in each category nationwide, and statistically valid estimates were developed to provide a "national" profile of mixed waste generation.

The estimates, published in June, 1993, indicate that approximately 139,441 cubic feet of mixed waste was generated in 1990. Of that amount, about 47% (65,000 cubic feet) was managed by incineration (i.e., liquid scintillation fluids, for example), or other treatment, leaving 53% (75,000 cubic feet) to be stored on site for lack of available treatment or disposal.

Table 8-2
Mixed Waste Streams (Potential) by Waste Type and Generator Category

Waste Type	Generator Category					
	Utilities	Health Care	Academic	Commercial	Government (non-federal)	Federal
Liquid scintillation fluids	X	X	X	X	X	X
Organic chemicals	X	X	X	X	X	X
Lead wastes	X	X	X	X	X	X
Chromates, cadmium wastes	X					X
CFC wastes	X			X		X
Aqueous corrosive liquids	X			X	X	X
Waste oil	X		X	X	X	X

Source: Adapted from U.S. EPA, Office of Solid Waste. Mixed Waste Training Course. Washington, DC, 1898/1990, and E.A. Jennrich (Rogers and Associates Engineering Corporation). Management Practices and Disposal Concepts for Low-Level Radioactive Mixed Waste. U.S. Congress, Office of Technology Assessment, Washington, DC, March, 1989.

Liquid scintillation fluids comprised the largest category of the nation's commercial mixed waste totalling 72%. Other organic liquids comprised 9.4%; oil totalled 6% and CFCs, 4.5%. Also reported were lead wastes, chlorinated organic liquids, chromium and cadmium wastes, and a group of "other" hazardous components that were not categorized.

The national mixed waste profile also revealed that, for 1990, the category producing the largest percentage of mixed waste nationwide was the commercial category, generating about 36% of the total volume. This statistic is comparable to the percentage of mixed waste produced by the commercial generator category in Massachusetts. Table 8-3 compares the national profile data with the average of mixed waste generation percentages for the years 1991 and 1992 of all categories of Massachusetts mixed waste generators.

A number of interesting comparisons can be made between the national profile data and the data on mixed waste generation in Massachusetts that is collected and analyzed yearly by the Management Board. The percentage of mixed waste produced by generators in the Massachusetts "health" category is almost twice as high as the national percentage. The percentage for the Massachusetts "commercial" category is higher than the national percentage, but lower for the Massachusetts "government" and "utility" categories. These statistics reflect the activities in the Commonwealth that result in LLRW generation. Commercial LLRW generation in Massachusetts, with its high volume of LLRW production from the manufacture of radiopharmaceuticals, is customarily a higher percentage than in most other states; the health care industry in Massachusetts, recognized nationally and internationally for its hospitals and clinics that diagnose and treat diseases using nuclear medicine practices, attracts patients from all over the world -- and thereby produces more LLRW; the utility generators in Massachusetts are a smaller percentage of the

total radioactive materials use, than in most other states.

Another similarity between the national profile data and the Massachusetts mixed waste stream is the presence of a large percentage of liquid scintillation fluids (over 82% of the Massachusetts mixed waste produced in 1991 and 1992). Like the data revealed from the national study, the portion is substantial of liquid scintillation fluid mixed waste that can be incinerated as either fuel (EPA provision) or as de minimis quantities (NRC provision), if it contains less than 0.05 microcuries per gram of Carbon-14 or Hydrogen-3. In fact, the report on the national study concludes that unlike other types of mixed waste, the liquid scintillation fluid category "does not, in general, currently pose a significant treatability problem, nor is it expected to in the future because of the adequate amount of commercial treatment capacity that currently exists and the increasing use of substitute materials."[13]

Table 8-3
Comparison of National Mixed Waste Generation and Massachusetts Mixed Waste Generation by Generator Category

Generator Category	National Profile - Weighted[1]		Massachusetts Average of 1991 and 1992	
	Volume	Percentage	Volume	Percentage
Academic	28,982	21	798	20
Commercial	50,430	36	1577	43
Government	26,500	19	327	7
Health	19,904	14	1210	28
Utility	13,276	10	77	2

[1] The "weighted" data represents the estimated mixed waste generation rate after "as reported" data was corrected to account for non-respondents and correct percentages of generators in each category, nationwide.

Source: U.S. Nuclear Regulatory Commission. National Profile on Commercially Generated Low-Level Radioactive Mixed Waste. NUREG/CR-5938 ORNL-6731. Oak Ridge, TN, December, 1992; and Low-Level Radioactive Waste Management Board. 1991 and 1992 Massachusetts Low-Level Radioactive Waste Survey Reports. Boston, MA, November, 1992, and October, 1993.

Federal Department of Defense (DOD) and DOE facilities also produce mixed waste in connection with production reactors, test reactors, certain Navy vessels, weapons manufacturing, research, and other activities. DOD waste volumes are not publicly known; until recently, imprecise approximations were made of DOE mixed waste volumes.

The Federal Facility Compliance Act of 1992 (FFCA) requires DOE to report on the various hazardous and radioactive waste streams it generates, as well as their capacity for treatment and disposal. DOE released its first report, "Interim Mixed Waste Inventory Report on Waste Streams, Treatment Capacities and Technologies," in 1993. The report identifies the volume of DOE mixed waste generated annually, and in storage, (for lack of treatment and disposal), and the volume expected to be generated over the next five years. The report also identifies 50 sites in 22 states that store, generate, or are expected to generate high-level radioactive mixed waste, transuranic mixed waste, and low-level radioactive mixed waste during the

[13] U.S. Nuclear Regulatory Commission. National Profile on Commercially Generated Low-Level Radioactive Mixed Waste. NUREG/CR-5938 ORNL-6731. Oak Ridge, TN, December, 1992.

next five years.[14] Massachusetts is not one of these states.

DOE reports that its total mixed waste volume currently in storage, combining all three waste classifications mentioned above,[15] is approximately 20,814,592 cubic feet, and the volume projected for the next five years is about 10,520,007 cubic feet. An additional 21,903,852 cubic feet of mixed waste is projected from DOE's environmental restoration projects.

At the end of 1992, Massachusetts generators reported that they had 31,722.2 cubic feet of LLRW in storage, accumulated over several years. It is not known what percentage of this accumulated waste may contain or exhibit hazardous characteristics, because some waste is reported as "unclassified." Moreover, these statistics may not present the entire picture of mixed waste in Massachusetts. Based on telephone conversations with LLRW generators, and the evaluation of some licensees' uses of radioactive materials and their volumes of waste produced, it appears that some smaller LLRW generators may not realize they are producing mixed waste.

Another reason for the possible under-reporting is addressed in sections 8.4 and 8.5 of this chapter. It relates to the conflicting regulatory requirements of NRC and EPA, and to the shortage of treatment and disposal for some types of mixed waste. As a result, generators are forced into a "Catch-22" situation: they must store mixed waste until treatment and disposal is available, even though EPA and DEP regulations prohibit them from doing so (except to accumulate enough mixed waste to ship for treatment or disposal). This is an understandable reason that some generators, fearful of future regulatory constraints, may be hesitant to acknowledge their mixed waste production.

In addition, some licensees have reported informally that they are not identifying residual materials in their possession as "waste" until EPA and NRC resolve the conflicts over this management issue.

The Massachusetts survey results are similar to other studies on mixed waste volumes. For example, a 1989 study conducted for the Office of Technology Assessment revealed that many generators believe the management practices used for LLRW are safe for mixed waste as well. Therefore, some mixed waste may be packaged for disposal as pure LLRW, and shipped to the disposal site in Barnwell, South Carolina. Because LLRW containers are rarely opened -- due to the need to prevent radiation exposure -- it is not known whether any packages in this disposal site contain unauthorized mixed waste.

8.4 Federal and State Regulatory Responsibilities

As stated, EPA and NRC share dual authority over mixed waste. EPA is charged with implementing RCRA and its amendments to regulate the hazardous portions of mixed waste, and NRC is charged with implementing the AEA to regulate the radioactive components of mixed waste.

EPA's control of hazardous waste begins when a substance is determined to be a waste, in contrast

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[14] The FFCA requires DOE, among other governmental hazardous and mixed waste generators, to report to the EPA and the states where DOE stores, generates, or treats hazardous or mixed waste. The FFCA also requires DOE to submit plans to each state or EPA for providing mixed waste treatment in centralized, regional, and/or on-site facilities. While such plans must be submitted for review and approval by October, 1995, DOE intends to publicize two "interim" versions to encourage discussion.

[15] The report does not separate the volumes of each of these three categories.

to NRC's authority which begins when a person takes title to or possesses source, special nuclear or byproduct material.[16] The "cradle to grave" control often attributed to hazaous waste management is therefore more applicable to the NRC licensing system, which puts responsibility on the user of radioactive materials from the moment the licensee takes possession of the material -- not its waste by-product generated at a later time.

Both of these agencies may delegate some regulatory control to complementary state agencies. The licensing of radioactive materials users that produce mixed waste, and of storage, treatment, and disposal facilities for mixed waste, may be assumed by states through the NRC's "Agreement State" program.[17] Control over the hazardous portion of mixed waste may be assumed by a state program authorized by EPA.

While neither such state program has been established in Massachusetts, both are in preparation. The Department of Public Health (DPH) intends to regulate radioactive materials, including those in mixed waste, and has adopted regulations required for Agreement State status, NARM rules, and those relating to storage, treatment, and disposal facilities. [105 Code of Massachusetts Regulations (CMR) 120.000] In addition, DEP is seeking EPA authorization to regulate the hazardous components of mixed waste under DEP's existing hazardous waste regulations. [310 CMR 30.00]

Unlike the NRC Agreement State program which requires that some state provisions be identical to NRC standards,[18] the RCRA-authorized hazardous waste state programs may always be more stringent than their EPA counterpart.

In addition, the EPA authorization does not preclude a state from independently regulating mixed waste under state laws and regulations, even though the state has not received mixed waste authorization from EPA, pursuant to RCRA. Thus, while in some states, EPA authorization is necessary to establish a mixed waste program, in Massachusetts, regulations of DEP have been adopted for mixed waste under the authority of Massachusetts General Laws c. 21C, the Hazardous Waste Management Act, and will continue to be implemented until the Commonwealth receives its EPA authorization for mixed waste.

As Massachusetts is not yet an Agreement State, the NRC will continue to regulate the radioactive components of mixed waste in the Commonwealth. Until EPA mixed waste authorization is granted, DEP and EPA will continue to regulate the hazardous components of mixed waste under their existing regulations.

NRC regulations applying to mixed waste generators are contained in 10 CFR Parts 20, 30-33, 35, 40, 61, 70, and 71. Because these provisions are described in detail in Chapters 2 (licensing), 3 (health protection standards), 4 (waste characteristics), 7 (classification), 9 (transportation) and 10 (waste

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[16] These various types of radioactive materials are described in section 4.1 of Chapter 4.

[17] The NRC does not, however, transfer to the states regulatory authority over certain licensees, including federal government users of radioactive materials and nuclear-powered electric generating plants.

[18] The degree of "consistency" with NRC regulations has been subject of considerable controversy of late. A task force representing an organization of Agreement States recommended to the NRC that existing consistency standards be modified to allow states greater flexibility than currently available. The NRC is expected to work with Agreement States to resolve this issue during 1993, due to the important role played by each Agreement State program in connection with the federal mandate that states assume responsibility for LLW in 1993. Massachusetts has argued that state programs should be given more flexibility than currently allowed by the NRC, to allow the state to establish more stringent standards, if it so chooses. See the discussion of this issue in Section 2.6 of Chapter 2.

minimization), they are merely summarized here.

Users of radioactive materials as defined by the AEA must have an NRC license to manufacture, produce, transfer, receive, acquire, own, possess, or use this material, and to receive, possess, store, treat, and dispose of the wastes generated from their use. Each licensed radioactive materials user is limited by his license to the quantity of radioactive material he can possess, and the waste he can dispose of.

Exemptions from licensure exist in the regulations for certain low concentrations of specific radionuclides and certain products, such as watches with hands or dials made with radioactive materials, clock illuminators, automobile shift quadrants, marine compasses, self-luminous products, and thermostat dials, for example, which contain specific, very small quantities of certain radioactive materials. [10 CFR 30.11-30.20]

Except for licensed users excluded due to the exemptions noted above, mixed waste producers must also comply with:

- various radiation dose limit standards governing workers who would come in contact with radioactive material, and individuals outside the locations where radioactive material is used; [10 CFR 20.101-20.106]
- requirements to maintain records regarding receipt of the radioactive material for three years following its transfer or disposal; [10 CFR 30.51(a)]
- provisions allowing inspection by NRC or Agreement State officials of the premises and the facilities where radioactive materials are used or stored; [10 CFR 30.52]
- requirements for testing radioactive materials, buildings where the materials are used or stored, radiation detection and monitoring instruments, and other equipment used in connection with radioactive material; [10 CFR 30.53]
- NRC and U.S. Department of Transportation (DOT) requirements to package waste for transportation; [10 CFR 71 and 49 CFR 100-199]
- requirements for stabilizing and classifying waste for disposal; [10 CFR 61.55-61.56] and
- provisions for labeling all waste packages; [10 CFR 61.57]

Users of certain quantities of radioactive materials whose half-lives are greater than 120 days[19] must also submit for approval to the NRC, decommissioning funding plans or certifications that financial assurance for decommissioning has been provided in the amounts required by the NRC regulations.[20] [10 CFR 30.35]

NRC regulations also apply to facilities established for the disposal of LLRW, including the radioactive portions of mixed waste. [10 CFR Part 61] These regulations include "performance objectives" to protect the public and workers from exposure to radioactive material, and to ensure long-term "stability"

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[19] The "half-life" of a radioactive material is the time required for the radioactive substance to lose 50% of its radioactivity by the process of decay, which is explained in detail in Chapter 3.

[20] "Decommissioning" is the process by which all radioactivity is reduced to a level that permits release of the property to "unrestricted use," and termination of the license.

of the site after it is closed. They also include certain technical requirements for "near-surface" disposal facilities,[21] such as minimizing upstream drainage, and avoiding 100-year flood plains, coastal high-hazard areas, wetlands, and areas subject to faults and other seismic activity.

In addition to the NRC regulations, state law requires similar standards for the licensing, development, operation, and closure of storage and treatment facilities, as well as disposal facilities, under the regulatory control of DPH. The DPH regulations will be effective once the State is authorized under the Agreement State program.

Storage, treatment or disposal facilities for mixed waste must meet an additional requirement, which is explicitly stated in Massachusetts General Laws c. 111H (Chapter 111H), the Low-Level Radioactive Waste Management Act. Section 16 of Chapter 111H requires that DPH regulations governing mixed waste "shall require an equivalent level of environmental protection" as is required by Massachusetts General Laws c. 21C, the state law pertaining to hazardous waste management.

State Hazardous Waste Regulations

Massachusetts DEP became authorized by the EPA on Feb. 7, 1985, for what is termed "base-RCRA authority" to regulate hazardous waste. The state regulations are similar to the EPA regulations in 40 CFR Parts 124 and 260-280.

Long after the Commonwealth and many other states had received basic authority over hazardous waste, EPA published Federal Register notices in 1986 and 1988 which clarified its requirements for authorization to regulate the hazardous components of mixed waste. The 1986 notice set a one-year deadline for states to demonstrate that their "base-RCRA authority" program applied to all hazardous waste, including mixed waste. Of the 44 states which had "base" authority when the notice was published, only four states (Colorado, South Carolina, Tennessee and Washington) received authorization to regulate radioactive mixed waste by the time the 1988 notice was issued.

The 1988 notice clarified that mixed waste storage, treatment, or disposal activities in states granted only "base program" authorization (like Massachusetts), are not subject to RCRA regulation until the state program is revised and approved to incorporate mixed waste authority. As stated, however, Massachusetts has independent authority to regulate mixed waste under state law, and mixed waste regulations are a part of DEP's hazardous waste regulations, 310 CMR Part 30.00.

Some of the basic requirements of DEP's program that pertain to the hazardous components of mixed waste include:

(1) There are three categories of hazardous waste generators:

Large quantity generators: produce over 1,000 kilograms (i.e., 2,200 pounds) per month of hazardous waste or over 1 kilogram (i.e., 2.2 pounds) per month of "acutely hazardous

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[21] A "near-surface" disposal facility is a land disposal method in which radioactive waste is disposed of in or within the upper 30 meters of the earth's surface. This type of disposal, if it amounts to nothing more than landfilling, is prohibited by Massachusetts law. However, any potential disposal facility site in Massachusetts must be evaluated using the NRC near-surface disposal criteria -- even if the facility is going to utilize other technologies for disposal, such as engineered above-ground vaults -- because these criteria are the only ones currently approved by the NRC.

waste."[22]

Small quantity generators: produce more than 100 kilograms (i.e., 220 pounds) but less than 1,000 kilograms (i.e.,2,200 pounds) of hazardous waste per month or less than 1 kilogram (i.e. 2.2 pounds) of acutely hazardous waste per month.

Very small quantity generators: generate less than 100 kilograms (i.e., 220 pounds) of hazardous waste per month and no acutely hazardous waste per month.

DEP regulations **exempt** any generator in the "very small quantity" group from all hazardous waste regulations except:

a. Registration (not licensure) by DEP;

b. Authority to determine when actions of the very small quantity generator may pose an "imminent threat" to the public health, welfare, safety or the environment;

c. DEP's determinations as to whether a waste is hazardous;

d. Recordkeeping and waste container labeling requirements; and

e. The general requirement that wastes be managed in a "manner which neither could nor does endanger public health, safety or welfare, or the environment, and in compliance with all other applicable local, state and federal laws and regulations." [310 CMR 30.353]

(2) Like all generators of hazardous waste, mixed waste generators must obtain an EPA identification number and keep track of all off-site waste shipments using an EPA-approved "manifest" form. [310 CMR 30.303 and 30.311]

(3) Mixed waste generators may not transport the waste off site unless the generator has a valid DEP license to transport mixed waste. [310 CMR 30.304]

(4) Mixed waste generators are prohibited from shipping waste to other than a DEP-licensed or EPA-permitted facility for the storage, treatment, or disposal of mixed waste (unless the state accepting the waste does not consider the waste to be mixed waste), or to a facility holding an EPA research, development, or demonstration permit. [310 CMR 30.305]

(5) Mixed waste must be labeled for off-site shipment in compliance with regulations of DOT, namely 49 CFR 172, as amended.[23] [310 CMR 30.322]

(6) Mixed waste generators must retain manifest records for at least three years [310 CMR 30.331]; "large quantity" mixed waste generators must annually report to DEP all shipments of wastes transported off site as well as all mixed waste treated, stored, used, or disposed of on site. [310 CMR 30.332]

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[22] Many hazardous wastes have been listed by EPA/state programs as being "acutely hazardous," due to their danger to human health and the environment.

[23] Please refer to Chapter 9 of this volume for a complete discussion of transportation requirements for all LLRW including mixed waste.

(7) A "large quantity" mixed waste generator may accumulate waste on site for 90 days or less, in compliance with packaging, container, and labeling regulations, without a DEP storage license. A generator of mixed waste that is stored on site for more than 90 days must be licensed for storage, and comply with some of the same provisions that apply to hazardous waste storage "facilities" (i.e., personnel training, financial assurance, closure plan, etc.). [310 CMR 30.340]

(8) A "small quantity" generator may accumulate hazardous waste "at or near each specific point of generation" for any length of time without a license if:

a. A key staff person is directly responsible for each specific point of generation;

b. Only one container (55 gallons of hazardous waste or one quart of acutely hazardous waste) is used at any one time.

(9) A generator who treats, stores, uses, or disposes of mixed waste on-site is regulated in the same manner as an operator of a hazardous waste storage, treatment, or disposal facility, and must be licensed by DEP with the exceptions outlined above. [310 CMR 30.801] Any treatment which is "an integral part of a manufacturing process at the site of generation" does not require a license.

Management standards for licensure of storage, treatment, or disposal facilities handling mixed waste include installing security barriers; conducting inspections; training facility personnel; handling "ignitable," "reactive" or "incompatible" wastes;[24] complying with siting standards; and providing for emergency preparedness, financial assurance, closure and post-closure, and corrective action.

DEP's regulations allow disposal facilities for the hazardous components of mixed waste to include landfills, as long as they incorporate into their designs two liners and leachate collection and leak detection systems. [310 CMR 30.622] This regulation, however, may be inconsistent with the prohibition against shallow land burial of LLRW, including mixed waste, contained in Chapter 111H.

In addition, DEP requires that all hazardous waste, including mixed waste, must be treated before it is disposed of pursuant to the federal Hazardous and Solid Waste Amendments (HSWA) to RCRA passed in 1984. This standard may become more restrictive than that administered by the EPA under RCRA, which will allow mixed waste disposal in a so-called "no migration" unit. In order to receive approval for such a petition from the EPA Administrator, a petition must successfully demonstrate that no hazardous wastes will migrate from the disposal unit for as long as the wastes remain hazardous. To date, no such petitions have been approved.

HSWA requires EPA (and therefore DEP) to establish regulations setting treatment standards for all listed and characteristic hazardous wastes, according to deadlines set in the law. Some of the treatment standards involve specific technologies required by EPA (such as incineration), and some set concentration thresholds which may be reached using various treatment technologies. Mixed waste currently is subject to the established treatment standards for the hazardous portion of the waste, with the exception of three categories of mixed waste: radioactive lead solids, radioactive elemental mercury, and radioactive hydraulic oil contaminated with mercury.

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[24] An "incompatible waste" is a hazardous waste that is unsuitable for (1) placement in a facility because it may corrode the materials used to contain the waste, or (2) commingling with another waste or material under uncontrolled conditions that may produce heat, pressure, fire, explosion, toxic dusts, or vapors, for example.

Treatment standards have been issued by EPA for dioxins, spent solvents, and most "California-list" wastes (see below), and are included in the DEP regulations.

All listed and characteristic wastes are divided into five groups. They are:

Solvents and dioxins This group of wastes, both radioactive and non-radioactive, are banned from land disposal (unless treated), effective Nov. 8, 1986, and Nov. 8, 1988, respectively.

"California List" wastes This category was originally established by California law prior to the passage of HSWA, and includes liquid wastes containing certain metals, free cyanides, PCBs, corrosives, and certain wastes (liquid and solid) containing halogenated organic compounds. The majority of these wastes are prohibited from land disposal (unless treated), effective July 8, 1987, although variances have been granted for some wastes due to lack of treatment capacity.

"First, Second and Third Third" wastes The rest of the listed and characteristic wastes were divided by EPA into thirds for EPA's announcements of regulatory requirements.. The "first third" group was banned from land disposal (unless treated), effective Aug. 8, 1988; the "second third" was banned as of June 8, 1989, and the "third third" were to be banned (unless treated) effective May 8, 1990.

Because of the lack of capacity nationwide to treat mixed wastes, on June 1, 1990, EPA announced a two-year national capacity variance for all mixed waste in the "first," "second," and "third third" groupings, effective through May 8, 1992. This variance from the prohibition on land disposal, unless the waste is treated, does not apply to solvent, dioxin, or California list mixed waste.

EPA's two-year variance was applauded by mixed waste generators, although many criticized the time period as too short to complete licensing requirements and obtain permits. On August 29, 1991, EPA published an enforcement policy on small quantities of mixed waste in storage, publicly affirming that it will give "low priority" to enforcement of its ban on on-site storage, as long as mixed waste disposal capacity continues to be unavailable, and mixed wastes are managed responsibly.[25] The enforcement relaxation applies only to mixed waste generators of less than 1,000 cubic feet per year of waste prohibited for land disposal, not to any mixed waste for which treatment or disposal is available.

8.5 Availability of Mixed Waste Treatment and Disposal

Since the initial announcement by EPA in June, 1990, of a two-year exemption for the requirements of the agency's treatment standards for hazardous (and mixed) waste, four commercial treatment companies have received the necessary EPA (or complementary state) licenses and permits to treat much, but not all, of the mixed waste generated in Massachusetts and nationwide. Each treatment facility is described, below, and summarized in Table 8-4.

Quadrex Corporation. Quadrex Corporation's facility in Gainesville, Florida, can process up to 400,000 cubic feet of liquid scintillation fluids each year. The processor accepts only scintillation fluids, which are accumulated by crushing the vials holding the fluids, and storing the liquid for treatment off site.

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[25] In May, 1992, EPA announced a "low enforcement priority" for mixed waste generated by DOE so that EPA could consider DOE's request for case-by-case extensions to the land disposal restrictions requirements for waste streams generated from its nuclear weapons plants and research laboratories. The DOE request involves 309 mixed wastes, 41 transuranic wastes, and two high-level mixed wastes.

Table 8-4
Mixed Waste Treatment Facilities

Company Name, Location	Mixed Waste Categories	Treatment Modes	Annual Capacity
DSSI, Kingston, TN	Aqueous solutions, liquid scintillation fluids	Incineration; storage for decay	130,000 cubic feet
NSSI/Recovery Systems, Houston, TX	Liquid scintillation fluids	Chemical oxidation, stabilization, recycling, chemical fixation, precipitation, charcoal absorption	750,000 cubic feet
RAMP Industries, Denver, CO	Liquid scintillation fluids	Storage for decay, broker fluids by bulk for incineration off site or toluene recovery	25,000 cubic feet
Quadrex Corp., Gainesville, FL	Liquid scintillation fluids	Washing, broker fluids by bulk for incineration off site	400,000 cubic feet

Sources: Kirner, N. et. al. Mixed Waste Management Options. U.S. Department of Energy DOE/LLW-134, Idaho National Engineering Laboratory and National Low-Level Waste Management Program, EG&G Idaho, Inc., Idaho Falls, ID, December, 1991; and U.S. Nuclear Regulatory Commission. National Profile on Commercially Generated Low-Level Radioactive Mixed Waste. NUREG-CR-5938 ORNL-6731, Oak Ridge, TN, December, 1992.

Quadrex is limited to 180 days of radioactive materials storage, and has a possession limit of 100 millicuries per year of all isotopes other than Carbon-14 and Hydrogen-3. The company is planning an expansion of its mixed waste treatment services, to include solvents and oil, but will need approval by the Florida Department of Environmental Regulation of an amendment to its treatment, storage, and disposal permit.

Diversified Scientific Services, Inc. (DSSI). DSSI, located in Kingston, Tennessee, can incinerate up to 130,000 cubic feet each year of liquid scintillation fluids and solvents. The boiler used to incinerate these wastes is part of a cogeneration plant, which provides heat for steam turbines that generate electricity. The stack contains a scrubber, baghouse, and HEPA filter to remove particulates.

RAMP Industries. RAMP Industries of Denver, Colorado, treats liquid scintillation fluids by crushing the vials to separate the liquid from the plastic and glass containers. The liquid is then sent to a local plant for solvent extraction of the toluene and other solvents. The remaining liquid is sent off site for incineration as fuel at a hazardous waste cement kiln. RAMP can treat up to 25,000 cubic feet of mixed waste each year.

NSSI/Recovery Services, Inc. (NSSI). NSSI, of Houston, Texas, treats liquid scintillation fluids and other similar organic mixed wastes by shipping them off site for use in cement kilns throughout Texas. The company, which can treat approximately 750,000 cubic feet of LLRW and mixed waste, uses chemical fixation, chemical oxidation/reduction, adsorption, neutralization, precipitation, and evaporation.[26] The company has a RCRA Part B permit to store and treat hazardous waste on site, but cannot dispose of mixed waste on the premises.

The national profile report on mixed waste concludes that due to the availability of the treatment facilities described above, ample capacity exists for the treatment of all but about 13% of the mixed waste

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[26] See the description of these treatment technologies in Chapter 10.

estimated to be generated by the commercial sector in the nation each year. The report indicates that the need for different treatment methods is highest for incineration (for organic and other materials); followed by stabilization; distillation and oxidation (of organic sludges); neutralization; microencapsulation; chemical reduction; and thermal recovery (for mercury and lead acid batteries).

The report also notes, however, that if DOE arranges to use the commercial mixed waste treatment facilities currently available, its capacity demands are so great (as noted, 20.8 million cubic feet already in storage, and 10.5 million cubic feet of new mixed waste generation over five years), that there could be a significant impact on the availability of commercial mixed waste services to commercial mixed waste generators.

Mixed Waste Disposal Capacity

Only one company in the United States has a Part B permit (issued by the Utah Division of Solid and Hazardous Waste) to dispose of mixed waste. This company is Envirocare of Utah, Inc., which operates a landfill for LLRW and mixed waste in Clive, Utah. Because the company is limited by its license to accept only low activity LLRW and mixed waste, this facility cannot currently solve the nation's entire mixed waste disposal problem.

8.6 Mixed Waste Management Perplexities

The dual regulatory system has caused a hodge-podge structure of mixed waste management that is cumbersome and costly for both government regulators and waste generators. Some regulations overlap. Examples include the requirements that mixed waste generators hold two licenses, satisfy two financial assurance standards and two sets of employee training guidelines, and carry out two differing record-keeping "manifest" provisions designed to track the waste from " cradle to grave."

Some regulations are contradictory. The requirements for handling liquid mixed wastes are one good example. Because regulations pertaining to LLRW prohibit the disposal of liquid wastes, LLRW generators customarily have solidified their mixed waste for both storage for decay, and storage for ultimate disposal. However, the HSWA standard for treatment of most mixed waste organic liquids is incineration. While liquid wastes that have been solidified with absorbents or other materials can be incinerated, this process is more expensive, and more burdensome than the direct incineration of liquid waste.

Therefore, a dilemma faces the generator: should liquid mixed waste be stored on site, to await a facility that may be able to incinerate the material? Or, should the waste be solidified for safer interim management? RCRA regulations allow storage on site of waste that has been treated. However, NRC guidelines and individual licenses prohibit long-term (more than five years) storage of any LLRW.

Other difficulties created by the dual regulatory scheme include:

- "Very small quantity generators" who produce less than 220 pounds per month of hazardous waste, are exempt from RCRA/DEP requirements, and therefore can dispose of their waste in landfills, without pre-treatment. In contrast, NRC regulations establish health and safety as a paramount policy, regardless of the amount of LLRW or mixed waste that is generated.

- One of the requirements originating from the HSWA land ban prohibits hazardous waste generators from storing on site except for the purpose of accumulating sufficient quantities to

either treat or dispose. But because no treatment and disposal facilities for all types of mixed waste are available nationally, mixed waste generators have no choice but to store on site. By doing so, they are in conflict with RCRA/DEP hazardous waste regulations. In contrast, NRC regulations encourage the use of on-site storage for decay of short-lived radionuclides. Such storage is illegal under RCRA/DEP regulations.

- RCRA/DEP regulations require that the owner or operator of a hazardous waste disposal facility retains liability for potential problems at the site for 30 years after the facility has closed. The owner/operator must provide financial assurance that his "post-closure care fund" will cover the costs of groundwater and air quality monitoring, and "maintenance of monitoring and waste containment systems" for the 30-year period. At the end of this "post-closure" term, the owner/operator is relieved of liability, and the site can be used for other purposes. RCRA/DEP regulations do not require any inherent waste retention beyond that time period.

  In contrast, NRC regulations set a five-year "post-closure" period to identify any potential site problems before the facility license is transferred (from the operator) to the state. However, following that five-year post-closure period, the facility begins its "institutional control" period, which may last from 100 up to 500 years or more, before the site becomes available for any other potential use. During the institutional control period, an "institutional control" fund, accumulated during the operating period of the facility from fees paid by facility users, and managed by the state treasurer's office, is available to handle any potential liability problems.

- RCRA/DEP requires weekly surveillance and inspection of mixed waste while in storage, in order to verify the contents of each container. The frequency of such inspections can give rise to serious problems with radiation exposure to workers. One study of radioactive materials users estimates that this frequency of inspections could increase the radiation dosage to workers to an unacceptable level, in contrast with the NRC requirement to keep radiation dose "as low as reasonably achievable." (ALARA)

- RCRA/DEP requires an inspection of the contents of each package as it enters a disposal facility, for content verification. Such a requirement is also contrary to NRC's ALARA requirement.

- In addition, RCRA/DEP requires sampling and analysis of each package of waste before it is accepted for disposal. The analysis requires the removal of a minimum 100-gram sample. In addition to the obvious contradiction between this requirement and the ALARA principle, some samples of certain high-radioactivity LLRW cannot be tested, as no laboratory in the country will conduct an analysis due to the radiation contamination and occupational exposure that would occur.

- RCRA/DEP requires that all hazardous waste must be treated prior to land disposal. This regulation is consistent to that of the NRC, which requires that LLRW be put into acceptable "waste form" for disposal. However, RCRA/DEP also stipulates that, prior to treatment, the TCLP test must be performed on any wastes whose toxicity levels are uncertain. In the case of many solid mixed wastes, like lead mixed waste, for example, the TCLP test requires that the materials be "ground" up for sampling to particle sizes no larger than 9.5 millimeters. No laboratory in the United States is currently willing to grind sealed radioactive sources that have lead shields. The EPA toxicity test therefore contradicts NRC regulations, which prohibits containers holding radioactive sources from being opened.

Another contrast between the two sets of regulations poses a greater difficulty for state regulators. Massachusetts LLRW management law **prohibits** the disposal of LLRW by shallow land burial, and requires waste monitoring and retrieval, as well as the removal of all LLRW from a facility at the end of the

institutional control period that continues to have radioactive contamination greater than the maximum concentrations above natural background levels permitted to be released into air or water under federal and state law. These requirements describe "long-term storage" more closely than "disposal." In contrast, the State's hazardous waste regulations **allow** landfill disposal, if double liners are installed to prevent the migration of hazardous contaminants. In order to meet both standards, any disposal (i.e., long-term storage) facility in the Commonwealth which may be built to accept mixed waste must not constitute shallow land burial, and must incorporate double liners. Because state LLRW law also requires that all LLRW disposal facilities be capable of monitoring and retrieving the waste, long before it could reach a liner, it is questionable whether the inclusion of the double liner system enhances the environmental protection of a mixed waste disposal facility, or merely adds costs without supplying extra environmental or public health protection.

The State of Nebraska, which is developing an above-ground vault, multi-engineered barrier LLRW disposal facility for the Central Compact region (Arkansas, Louisiana, Nebraska, and Oklahoma), has determined that the costs of building a mixed waste disposal vault would amount to approximately $12,000 to $15,000 per cubic foot for mixed waste in comparison to about $200 per cubic foot for non-mixed LLRW waste disposal. Concerned that their mixed waste costs will: (1) encourage mixed waste generators to reduce further the quantities they are producing, resulting in a very costly, and under-utilized Central Compact mixed waste disposal site;[27] or (2) cause mixed waste generators to disguise their mixed waste as non-mixed LLRW in order to pay the lower disposal costs, Nebraska has opted **not** to build disposal vaults for mixed waste, at the present time. California, which is hosting a disposal site for the Southwest Compact (Arizona, North Dakota, South Dakota, and California), has made the same decision and will not develop mixed waste disposal capacity until a later time, if ever.

Nebraska and California organized an effort through a national organization of state LLRW management officials (the LLW Forum), in which Massachusetts is an active participant, to convince DOE to take all non-federal government-generated mixed waste in the country, since DOE produces approximately 90% of all mixed waste. Whether or not the current discussions will be successful among states, DOE, and the NRC – which also supports the DOE plan, is unknown at this time. However, strong motivation exists to have DOE utilize one or more of its many federal research facilities for the development of mixed waste treatment and disposal facilities.

Besides treatment and disposal, there are a number of other options to consider in managing mixed waste. The best alternative is to avoid the initial production of this waste, which is sometimes possible through the substitution of products or changes in manufacturing processes.

Short of these strategies, the next best management option is to treat the mixed waste to remove either the radioactive components or the hazardous components, thereby rendering the waste only radioactive, or only hazardous, and allowing more disposal options to be available. Unfortunately, many mixed wastes are commingled and are not easily separated.

RCRA Regulatory Options

Three alternatives to the EPA treatment requirements exist in RCRA and are copied in the DEP hazardous waste regulations. They include "delisting" a waste under 40 CFR 261, or obtaining a "no migration" variance, or a "treatability" variance under 40 CFR 268. Each is summarized below.

Delisting. EPA accepts three circumstances under which a waste from one of its lists may not

[27] While mixed waste minimization is excellent public policy, it has a direct economic effect on the development of mixed waste disposal facilities, escalating disposal costs per cubic foot of waste.

actually be hazardous: (1) the waste does not contain the components or exhibit the hazardous characteristics for which it was originally listed; (2) the hazardous constituents are present in small amounts; or (3) the hazardous components are present in an immobile form. In order to receive approval for a delisting petition, the waste generator must demonstrate that the treated waste is no longer hazardous. Extensive and costly requirements for waste analysis, groundwater monitoring data, descriptions of the operations that produced the waste, and procedural requirements, have reduced consideration of this option. EPA staff estimates that a delisting petition could cost $100,000 dollars or more, and take an average of two years to review.

No migration variance. Approval by EPA of a no migration variance would allow storage or disposal of mixed wastes without the required EPA treatment. However, approval is difficult to obtain. RCRA requires that a petition for a no migration variance demonstrate "to a reasonable degree of certainty that there will be no migration of hazardous components from the land disposal unit or injection zone for as long as the wastes remain hazardous." [Section 3004(e)] EPA requires the submission of extensive information describing: the waste sources and characteristics; the facility design and operations; characterizing the site; monitoring plans; assessing the environmental impacts; predicting infrequent natural phenomena; and quality assurance. Costs for the application and review are estimated to range from $100,000 to $500,000, and take a minimum of two years.

Treatability variance. Wastes that are quite different from those considered by the EPA when it adopted its treatment standards may be considered for variances from those standards. Such a variance would allow alternative methods of treatment than those required by EPA regulations. In order to receive a variance, the generator or facility operator must prove that the EPA treatment standard cannot be achieved. EPA requires the submission of information describing: the waste; the processes and materials resulting in the waste generation; the reasons the treatment standards are not achievable; other treatment technologies investigated by the petitioner and the achievable results in waste concentrations; the testing methodology; and certification of accuracy. Application costs are estimated at $40,000, and review averages four months to a year.

Massachusetts DEP regulations include provisions for delisting [310 CMR 30.142], no migration variances [310 CMR 30.755] and treatability variances [310 CMR 30.775]. All these regulations are equivalent to the EPA standards. However, EPA has not authorized the State to review and grant these petitions. Therefore, review and approval remains with EPA. Only three states hosting LLRW disposal facilities are authorized by EPA to review and approve delisting petitions. They are Illinois, Nebraska, and New Jersey. No states have review and approval authority over either "no migration" or "treatability" variances.

Meeting Dual Regulatory Requirements

Despite the difficulties listed above with dual regulation, EPA and NRC have been working for several years to develop practical, workable approaches to mixed waste regulation. The two agencies have issued four joint guidance reports, pertaining to:

(1) the definition of mixed waste (see section 8.2 of this chapter);

(2) siting requirements for a mixed waste disposal facility;

(3) a conceptual design for a mixed waste disposal facility that will meet both EPA and NRC regulations; and

(4) a "draft" guidance clarifying the RCRA hazardous waste testing requirements for mixed waste.

Additional joint guidance is being developed on safe storage of mixed waste, and is expected to address on-site storage, container requirements, inspection and surveillance, waste compatibility and segregation, and time limitations on untreated waste. Due to the current lack of treatment and disposal capacity for some mixed waste, these new guidance policies will be welcome to concerned mixed waste generators and state regulators.

8.7 Mixed Waste Management Recommendations

The Management uncertainties regarding mixed waste that have been described in this chapter include:

- the lack of accurate information about the quantity and types of mixed waste generated;
- long delays by federal agencies to agree on workable rules and regulations to handle mixed waste materials presently in storage;
- dual regulation by NRC and EPA (or DPH and DEP once the state programs receive authorization);
- inconsistences in the dual regulatory structure;
- absence of treatment options for all types of mixed waste;
- lack of disposal capacity for all types of mixed waste; and
- costs of mixed waste management.

Because the federal Low-Level Radioactive Waste Policy Amendments Act of 1985 requires states to assume responsibility for disposal of all LLRW, including mixed waste, Massachusetts must establish policies for managing mixed waste in connection with its decisions about LLRW and hazardous waste. A portion of the policy framework is already in place: DEP's hazardous waste regulations currently apply to mixed waste generators in the Commonwealth. DEP's application for mixed waste authorization under the RCRA system will further enhance DEP's regulatory authority.

And, likewise, the State's current application for Agreement State status, once approved, will ensure that the regulation of the radioactive components of mixed waste -- including mixed waste generators and mixed waste storage, treatment, and disposal facilities -- will be assumed by DPH.

The following additional mixed waste management policies and recommendations are suggested to complement existing policy:

Reliable mixed waste data. In order to manage mixed waste properly, the Commonwealth needs to ensure a reliable data base on mixed waste generation, storage, treatment, and disposal. The annual radioactive materials users survey, conducted pursuant to Chapter 111H, section 7, should be used as a tool to collect such information. In addition, the Commonwealth (i.e., either the Management Board, DEP, DPH, or more than one of these agencies in cooperation), should hold meetings, workshops, and other informational sessions with licensed radioactive materials users to help educate them about mixed waste management issues.

Mixed waste minimization. All generators of mixed waste are required to prepare and implement plans for appropriate source minimization, volume minimization, and storage for decay, pursuant to section 13 of Chapter 111H. DPH, responsible for establishing a minimization program and adopting regulations to implement such a program, should include provisions in its regulations to require:

- Substitutions of materials and processes that, to the greatest extent possible, are economical, protective of the public health and the environment, and retain the quality of the material or product of interest, which will eliminate or reduce mixed waste; and

- All treatment practices that, to the greatest extent possible, are protective of the public health and the environment, economical, and retain the quality of the material or product of interest, which will eliminate the radioactive components of mixed waste.

Eliminate or reduce dual regulations. DEP should modify its "applicability" provision in 310 CMR 30.500, which currently prohibits the use of the "storage for decay" treatment method for mixed waste containing short half-life material. With a change in that regulation for short half-life mixed waste, the radioactive contaminants of the waste could decay to natural background levels with essentially no radioactivity remaining, and thereby change the mixed waste into "hazardous waste," for which there is treatment and disposal available. In addition, DPH and DEP should establish an inter-agency task force to identify duplicative and inconsistent regulations and develop procedures for their reduction or eradication within the bounds allowed by EPA and NRC. The task force should concentrate its initial efforts on modifying 310 CMR 30.500.

Treatment practices. Information on treatment technologies and practices available for mixed waste, as well as the locations of treatment facilities, should be disseminated routinely to all radioactive materials licensees through written materials and seminars. Annual survey questions should be designed to test the licensees' knowledge and awareness of treatment potential.

An ongoing information exchange should be promoted through organizations representing radioactive materials users and professional societies to share published materials on mixed waste management, especially minimization and elimination.

Mixed waste disposal. All realistic alternatives for the disposal of mixed waste will be explored by the Management Board. Such alternatives include, but are not limited to, negotiations with DOE for the development of a mixed waste disposal facility at an existing DOE research site, for use by both federal and non-federal mixed waste generators; and negotiations with other states who plan to accept mixed waste at their disposal facilities.

If an LLRW disposal facility is sited within Massachusetts, and no out-of-state mixed waste disposal solutions are available, the consideration of mixed waste acceptance will be carefully evaluated by the Management Board in conjunction with its review and approval of waste acceptance criteria under Chapter 111H, section 38.

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Chapter 9: Packaging and Shipping LLRW; Emergency Preparedness and Response

9.1 Introduction

Low-level radioactive waste (LLRW) has been shipped throughout the United States for over 40 years. Just as accidents have occurred in the transport of other types of wastes and the materials that produced them, some LLRW shipping accidents have occurred. However, no deaths or serious injuries have ever resulted from the radioactive contents of shipments released in accidents.

The accident record of LLRW shipments has been excellent during the past 22 years in which records have been maintained.[1] During that entire period, only 54 transportation accidents have occurred, involving about 1,000 LLRW packages. Of those 54 mishaps, only five involved the release of any LLRW. Appendix 9A briefly summarizes the 49 accidents in which no radiation was released.

Despite this admirable safety record, the public is concerned about LLRW transportation. Public apprehension stems from the fact that the shipment of LLRW brings this waste close to individuals who would not normally be involved with radioactive materials or waste. Despite the detailed requirements imposed on LLRW shipments, citizens also are concerned about the issue of packaging for safe transport and for waste disposal.

In some instances, public anxiety has led to the adoption of state and local transportation regulations, such as restrictions on the times waste shipments may occur, and on the routes they may follow. These restrictions, and ones imposed by the U.S. Department of Transportation (DOT) and the U.S. Nuclear Regulatory Commission (NRC), are examined in this chapter.

Also presented in this chapter are an evaluation of transportation routes, emergency preparedness and response, and enforcement capabilities in the Commonwealth, and recommendations to enhance LLRW transport.

Appendix 9B contains a detailed description of the legal and institutional requirements and procedures involved in moving one shipment of LLRW from Massachusetts to Hanford, Washington, for disposal by one of the State's largest LLRW generators (by volume and activity[2]).

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[1] A national Radioactive Material Incident Report database is compiled and maintained by the U.S. Department of Energy (DOE) at its Sandia National Laboratories in Albuquerque, New Mexico. Members of the public can access the database by contacting the database manager at (505) 856-1635.

[2] "Activity" means the rate of disintegration or decay of radioactive material. Activity is often measured in "curies," which represent the quantity of any radionuclide that undergoes 37 billion disintegrations per second.

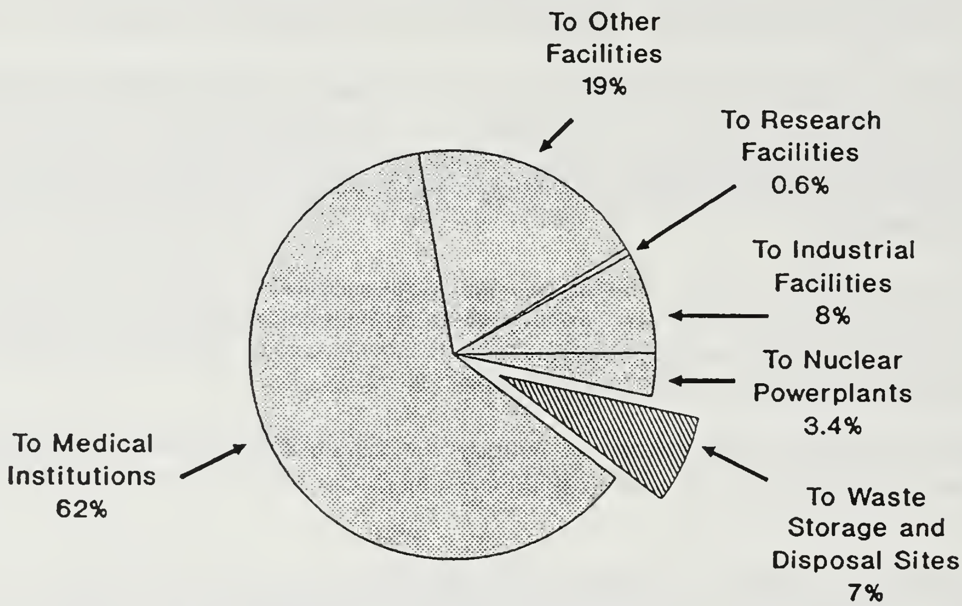
9.2 History of LLRW Transportation

Over 500 billion shipments of all kinds of goods are estimated to be transported throughout the United States every year. Of that number, only about 0.02% (one out of every 5,000) of the total shipments involve hazardous materials, the broad category of toxic chemicals and wastes that includes radioactive materials and radioactive wastes.

Of the annual hazardous materials shipments, about one in 50 (i.e., two million) involves radioactive materials, involving about 2.79 million packages. Of these two million radioactive materials shipments (which constitute only 2% of the total number of hazardous materials shipments each year), LLRW shipments account for only about 7%, or approximately 140,000 shipments each year. Of those 140,000 LLRW shipments that occur nationally each year, an average of 600 (0.43% or less than one-half of 1%) involve LLRW shipments by Massachusetts-based generators.[3] Waste shipments move through the country predominantly by truck, but rail and water transportation systems are also employed.

A breakdown of radioactive materials and LLRW shipments nationally is shown in Figure 9-A.

Figure 9-A
Radioactive Materials and Waste Shipments



Source: U.S. Department of Energy. Transporting Radioactive Material, DOE/DP-0064, Washington, DC, August, 1989.

Of the approximately 450 radioactive materials users licensed in Massachusetts,[4] about 200

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[3] This Massachusetts LLRW shipment level is based on data from the Low-Level Radioactive Waste Management Board's annual surveys of radioactive materials users in the Commonwealth. Chapter 4 of this volume provides more detail about the characteristics of Massachusetts LLRW.

[4] The total number of radioactive materials users in Massachusetts varies from time to time due to the expiration or termination of some licenses, and the issuance of new ones.

generate LLRW each year, which can be stored for decay on-site and/or must be shipped to a licensed LLRW disposal facility. At the present time, about 100 licensees produce waste that must be transported to a facility for permanent disposal because the radionuclide content in the waste cannot be stored on site for decay.

As has been noted elsewhere in this Management Plan, only one commercial disposal site is available to take all types of LLRW produced in Massachusetts.[5] The Beatty, Nevada, and Hanford, Washington, regional disposal sites that had accepted Massachusetts waste up through December, 1992, are no longer available to the LLRW generators in the Commonwealth. Access to the commercial site still operating -- in Barnwell, South Carolina -- is available only until June 30, 1994, through a contract which the Massachusetts Low-Level Radioactive Waste Management Board successfully arranged with the regional entity that controls Barnwell access.

While it is hoped that access to the Barnwell site may be extended beyond June, 1994, its availability will cease at some point. As a result, activities involving the shipment of LLRW may change in the Commonwealth, when LLRW generators are forced to use on-site storage for all waste generated, not just that which can be stored for decay.[6]

With the possibility that only one limited disposal site will be available to Massachusetts LLRW generators after mid-1994, the number of LLRW shipments will decline. Some waste transport will still occur, however, as many of the larger waste producers will likely ship waste to out-of-state treatment facilities for supercompaction, incineration, or other treatment.[7] That waste will then be returned to the individual generators in Massachusetts for interim storage, lasting up to a five-year limit imposed by the NRC in guidance to generators who will be stuck with-out disposal capacity.

Regulation Prior to 1974

Responsibility for regulating transportation activities has historically been shared by federal, state, and local governments. The federal government's authority over transportation derives from the Commerce Clause of the U.S. Constitution, which is intended to promote and protect the free flow of interstate commerce. Unless Congress explicitly mandates otherwise, the Commerce Clause prevents states from restricting interstate commerce.

The two federal agencies that have primary responsibility for regulating LLRW are DOT and NRC. State and local governments have used their inherent powers to protect the health and safety of their citizens on the highways within their jurisdictions. Numerous regulations governing the transportation of LLRW have been adopted by states and localities, many of which are more restrictive than federal requirements. The issue of federal pre-emption over state and local laws is discussed in section 9.5 of this chapter.

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[5] One other site is available for the disposal of certain low radioactivity-high volume LLRW, such as soils from a decommissioning project. This site, run by Envirocare of Utah, Inc., and located in Clive, Utah, is not licensed to accept all types of LLRW, however.

[6] "Storage for decay" is a procedure in which LLRW with a relatively short half-life is held for natural radioactive decay in compliance with applicable federal and state regulations. Once the radioactivity of the waste has decayed to safe, background levels, the waste is no longer considered LLRW, and instead can be disposed of as regular, industrial trash.

[7] Chapter 10 describes various treatment methods to reduce LLRW volumes and make it more stable for future disposal. Chapter 12 discusses LLRW storage issues.

The control of LLRW shipments was covered by general DOT regulations until 1968, when DOT's Hazardous Materials Regulation Board published amendments to the agency's regulations which substantially conformed to standards published the year before by the International Atomic Energy Agency.[8]

State Surveillance Program

During the 1960s and early 1970s, state officials, environmental organizations and the public raised concerns over health and safety aspects of transporting radioactive materials, including LLRW. In 1973, DOT and NRC established a cooperative "state surveillance" program to collect data about radioactive materials transportation. These federal agencies received assistance from state and local radiological health agencies to review shipping procedures, packaging requirements, and exposure to workers handling radioactive materials.

The study, published in 1978, concluded that transportation of radioactive materials and LLRW does not present a significant health or safety hazard to the public.[9]

Ten states participated in the state surveillance program, including the three states that through 1992, accepted almost all of the nation's commercial LLRW (South Carolina, Nevada, and Washington). The goals of the surveillance program included:

- observing the physical condition of packages entering the disposal sites;
- recording radiation levels during transportation;
- monitoring radiation doses to transportation workers; and
- checking compliance by radioactive materials licensees with packaging, labeling, and other transportation requirements.

Transportation Violations Lead to Actions by Three Sited States

The inspections of vehicles entering the LLRW disposal facilities of the three sited states under the NRC/DOT surveillance study demonstrated the need for increased inspection and enforcement authority by federal regulators. For example, the Barnwell, South Carolina, disposal site experienced several types of violations: (1) roadworthiness of the vehicles and missing or inadequate shippers' paperwork; (2) radiological violations from leaking, improperly sealed, or excessively radioactive packages; (3) improper labeling or placarding discrepancies, and (4) lack of (or loose) tie-downs, braces, or other restraints.

The inspection results also led to a unified effort by the governors of those three states to press for passage of federal legislation to end their status as the only commercial disposal sites for the entire nation.

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[8] The International Atomic Energy Agency (IAEA) developed international regulations for the safe transportation of radioactive materials (including LLRW) at the request of the United Nations' Economic and Social Council. Initial IAEA regulations were published in 1961 and revised several times until their "Regulations for Safe Transport of Radioactive Materials, Safety Series No. 6" was published in 1967. The IAEA regulations have been adopted by most nations involved in radioactive materials and waste transportation, and are updated about every 10 years. Another update of "Safety Series No. 6" is pending.

[9] Los Alamos Scientific Laboratory. Summary Report of the State Surveillance Program on the Transportation of Radioactive Materials. NUREG-0393, U.S. Nuclear Regulatory Commission, March, 1978.

In July, 1979, the governors of the three states expressed serious reservations about the shippers' disregard for transportation rules, insufficient inspection and enforcement, and the lack of corrective measures. The Nevada and Washington governors closed their sites and asked NRC and DOT to upgrade inspection and enforcement activities. NRC responded with a plan that included federal inspectors at all three sites.

The transportation-related problems encountered during this time at the Beatty, Nevada, site caused the end of that site's use as a national disposal site. In May, 1979, a truck fire and a leak of contaminated liquid on two shipments heading for Beatty caused the state to strengthen its inspection activities. Every shipment was inspected. Radiation levels were checked; shipping papers and placards were inspected; all packages were checked for their integrity, labels, and external radiation levels. In addition, emptied trucks were monitored before leaving the site to ensure that no surface contamination existed.

In June, 1980, Nevada established a permitting system for all shipments received at Beatty, and suspended permits if serious noncompliance occurred. Shippers were also required to establish quality assurance programs to prevent recurrences of any noncompliance activities.

The following year, Nevada established a requirement for third-party inspections of all packages sent to its disposal site. Shippers were inspected four times a year on an unannounced basis. Shortly after the inspection system was instituted, the Nevada Legislature passed a law allowing administrative penalties to be assessed for violating any state law or regulation. These new policies served as a disincentive to many licensees, who chose not to pay the Nevada fees in favor of less costly disposal in South Carolina and Washington.

9.3 Federal and State Regulatory Authority

In 1974, Congress passed the Hazardous Materials Transportation Act (HMTA) (enacted on Jan. 2, 1975), and the DOT adopted additional regulations governing hazardous materials (including radioactive materials and LLRW). Those regulations appear in Title 49 of the Code of Federal Regulations (CFR), Parts 100-199. In 1990, amendments to HMTA were adopted (the Hazardous Materials Transportation Uniform Safety Act - HMTUSA).

HMTA authorizes DOT to establish standards relating to "any safety aspect" of the transportation of hazardous (including radioactive)[10] materials by any mode of transportation. HMTUSA clarifies whether federal or state laws take precedence, and mandates certain training for emergency response personnel.

In addition to the DOT authority, the NRC has regulatory power over some aspects of LLRW transportation. It derives its authority from the Atomic Energy Act of 1954 (AEA) which allows it to license and regulate "the receipt, possession, use, and transfer of radioactive materials."

DOT and NRC coordinate their activities on LLRW transportation under a memorandum of understanding revised in June, 1979. DOT's authority includes developing the overall safety standards governing all LLRW packages; classifying them for various uses, and their marking and labeling. If the

[10] Radioactive materials are defined in federal law as a subset of "hazardous" materials, those materials and waste containing toxic chemicals. Packaging and shipping standards for radioactive <u>materials</u> are the same as those for <u>LLRW</u>; however, this chapter refers only to LLRW regulations, since it is the <u>waste</u>, and not the radioactive <u>materials</u>, which is the subject of this Management Plan.

contents of a package exceed a Type A quantity,[11] or involve "fissile" materials,[12] the NRC must review and approve the package design.

DOT is responsible for safety standards involving the mechanical conditions of the transportation equipment; qualifications of drivers; loading and unloading; handling and storage (during shipment), and the placarding of transportation vehicles. DOT has also established requirements for notification and reporting of transportation incidents that may involve radioactive contamination.

The NRC's main involvement in radioactive materials and waste transportation relates to regulating shipments of spent fuel from nuclear-powered utility plants (high-level radioactive waste) and "highway route controlled quantities" of LLRW requiring "Type B" packaging. NRC also provides technical assistance to the DOT and aids in inspections, investigations of "incidents" or "accidents," and enforcement.

As defined by NRC, an "incident" is the actual or suspected release of radioactive material, or surface contamination exceeding regulatory requirements, on either the package or the transport vehicle. An "accident" involves the vehicle transporting the waste, and can range from a minor accident to a major collision. It does not involve the release or suspected release of radioactive material. Accidents are further categorized into "transportation accidents" and "handling accidents" to differentiate between accidents occurring during transport, and those involving the shipping container which occur during loading, handling or unloading operations.

Other Federal Roles

In addition to DOT and NRC, which maintain lead federal authority over LLRW transportation, there are other federal agencies with regulations relating to LLRW shipments:

U.S. Environmental Protection Agency (EPA). The EPA has broad authority under the Resource Conservation and Recovery Act (RCRA) of 1976 and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980 to regulate LLRW and emergency response because LLRW is defined under the broader category of hazardous materials. RCRA regulations apply only to LLRW that is mixed with materials listed as hazardous waste or which exhibit toxic, or other hazardous chemical attributes (known as "mixed" waste). One such RCRA regulation mandates that hazardous waste shippers must file a "manifest system" to track shipments from "cradle to grave" (i.e., from the location where the hazardous waste was produced to the location where it is disposed). This manifest requirement for "mixed" waste shipments (see Chapter 8 on mixed waste) is similar to the manifest requirement of DOT regulations.

Interstate Commerce Commission (ICC). The ICC regulates the rates of shipping companies, and issues certificates granting interstate transportation companies authority to transport LLRW among states.

U.S. Postal Service. The Postal Service regulates LLRW shipped through the mail.

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[11] Type "A" quantity radioactive material may be transported in Type "A" packaging. DOT regulations define this packaging as that which is adequate to prevent loss or dispersal of the radioactive contents and to retain the efficiency of its radiation shielding properties under normal transport conditions. Type "A" packaging, which is described later in this chapter, will continue in use until new DOT regulations are issued in response to the 1990 HMTUSA statute.

[12] "Fissile" materials are Plutonium-238, Plutonium-239, Plutonium-241, Uranium-233, Uranium-235 or any material containing these radioactive elements. These are specifically regulated by the NRC because of their ability to cause a nuclear chain reaction (fission) if sufficient amounts of these materials are in one location.

U.S. Coast Guard. The Coast Guard regulates LLRW transported in United States territorial waters.

Federal Aviation Administration (FAA). The FAA, in addition to the DOT, regulates LLRW shipments in the air.

State Regulatory Agencies

At the state level, the Massachusetts Department of Highways (formerly called the Department of Public Works) is responsible for public roads in the Commonwealth, and has adopted DOT regulations pertaining to radioactive materials and waste shipments as part of the larger category of "hazardous materials" regulations. [720 Code of Massachusetts Regulations (CMR) 8.00]

The Department of Highways' regulations prohibit vehicles from transporting LLRW (and radioactive materials) through the tunnel on the John F. Fitzgerald Expressway (Southeast Expressway) located beneath Dewey Square in Boston. [720 CMR 9:08(4)][13]

In addition, the Department of Highways has regulations on the weights and sizes of trucks which may carry any types of shipments, including LLRW. Overweight or oversize LLRW shipments must receive special permits, and are restricted to certain routes listed in the Department of Highways' regulations. [720 CMR 7.14, Attachment A] Limits on gross vehicle weight are generally set at 46,000 pounds for two-axle vehicles, and 80,000 pounds for three-or-more-axle vehicles.

Other state agencies that regulate LLRW transportation include:

Department of Public Health (DPH). DPH adopted regulations in January, 1994, updating its existing regulations governing the protection of the public against hazards associated with LLRW transportation, including inspection and enforcement procedures. [Massachusetts General Laws c.111, sections 5M-5P] These regulations are part of the requirements for state regulation under the "Agreement State" program. (See Chapter 2)

Massachusetts Turnpike Authority. As an independent "authority," the Massachusetts Turnpike Authority has its own regulations controlling the use of the Massachusetts Turnpike. Vehicles transporting LLRW (and radioactive materials) are permitted on all portions of the Turnpike except the Callahan and Sumner tunnels in Boston. [730 CMR 3.04(2)(n)] Any overweight or oversized vehicles carrying these materials or wastes are required to receive special hauling permits [730 CMR 5.06, Appendix 2] and are prohibited from using the Boston Extension of the Massachusetts Turnpike during morning and evening rush hours. [730 CMR 5.06, Appendix 2(7)]

In addition, any accident on the Turnpike involving a vehicle carrying LLRW or radioactive materials which results in death, injury, or property damage must be reported to the State Police. [730 CMR 5.04(7)]

Massachusetts Emergency Management Agency (MEMA). MEMA coordinates state resources in the event of an incident.

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[13] There are exceptions to the restriction, however, for the transport of radioactive materials and LLRW that are exempt from all Interstate Commerce Commission specifications because of the extremely small quantities, or types, of material or waste being shipped. The exemption also allows the shipment of non-liquid radioactive materials produced as manufactured products which weigh less than 500 pounds per vehicle. [720 CMR 9:07(1)]

State Police, Department of Public Safety. The Massachusetts State Police have the authority to enforce federal hazardous materials transportation regulations. [Massachusetts General Laws c.90, section 31]

9.4 Regulatory Requirements for LLRW Transportation

Because most of the LLRW in Massachusetts (and in the nation) is transported by truck, the regulations of the DOT are the major standards followed for waste shipments. DOT regulations refer specifically to radioactive "materials," of which LLRW is a subcategory. This section summarizing the regulations only mentions LLRW, although the language used in the regulations refers to radioactive "materials."

The three major objectives of the DOT regulations that ensure the safe transport of LLRW are:

(1) technical packaging standards;

(2) operational standards for proper handling and safe transport, and

(3) adequate enforcement procedures.

Packaging and operational standards are based on the type of potential hazard, or the degree of the hazard, that each LLRW represents. Hazards include:

Contamination hazards: those associated with individual contact with LLRW. Packages must be designed to contain the wastes inside under normal stress conditions of transport.

Radiation: which can pass through packaging and shielding. This hazard requires that limits on the quantity or concentration of radionuclides in the package be enforced to ensure that no excessive radiation is measured on the outside of the package.

Exposure to heat: which can be controlled through limits on package contents (quantity and concentration), package design, and remote handling of the packages.

Nuclear criticality: the possibility that enough fissionable materials can be in one location to result in a nuclear chain reaction. Regulations of the NRC limit the amounts of fissionable materials placed in a single package, and also require state notification, escorts, and special routes to prevent sabotage or hijacking if high concentrations of fissile materials are to be transported.

DOT Objective 1: Technical Packaging Standards

The types of packages used for shipping LLRW vary in size, shape, and weight. They can be fiberboard boxes for certain very low-activity packages;[14] 30- or 55-gallon steel drums or 100-ton steel casks for shipping irradiated hardware from nuclear power plants.

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[14] Fiberboard boxes are acceptable under DOT regulations for transporting certain "low specific activity" materials. However, this type of container is **not** permitted under NRC regulations for use in an LLRW disposal facility. Fiberboard boxes may be used to ship radioactive sources and products, and to transport treatable LLRW to a processing facility.

DOT's regulations were developed to protect the public and drivers and handlers of LLRW shipments by limiting radiation emissions on the package surface and by requiring increased shielding through package strength and durability, as the amount of activity increased in the container. Package requirements are based on three general considerations:

(1) The specific radionuclides to be shipped, as each varies to the degree of hazard involved;

(2) The quantity of radionuclides to be shipped, as more concentrated radioactive materials and wastes require more protective packages; and

(3) The form of the radionuclides, which DOT defines as "normal form" and "special form."

DOT's regulations are based upon the potential inhalation dose to the public in the event of an incident where 0.1% of the package contents would be released, and then 0.1% of the released amount might be taken into the body of an individual in the vicinity. Tables in the DOT regulations provide individual dose-related values for approximately 250 radionuclides. [49 CFR 173.435] The values are used to classify individual packages.

DOT regulations distinguish two specific "forms" of radioactive materials, "special" and "normal." Special form material is a non-fragile radioactive material that satisfies the following conditions:

(1) It is either a single solid piece or is contained in a sealed capsule that can be opened only by destroying the capsule;

(2) The piece or capsule has at least one dimension not less than five millimeters; and

(3) It satisfies the test requirements of 49 CFR 173.469(b) which include the following:

> The Department of Energy, which ships radioactive materials for federal research and development activities, estimates that DOT and NRC packaging standards keep radiation exposure down to a level such that an individual living near the route of a vehicle carrying the highest level of radioactive waste (i.e., high-level waste) would receive a dose ranging from one-hundred thousandths of a millirem to eight thousandths of a millirem per shipment. If 100 high level waste shipments passed by the house yearly, the residents would receive an additional dose of less than one millirem per year above normal background radiation.

(a) Impact test. A specimen of the special form material must fall onto a flat, rigid surface from a height of not less than 30 feet.

(b) Percussion test. The specimen shall be placed on a sheet of lead that is supported by a smooth solid surface, and be struck by the flat face of a steel billet to produce an impact equivalent to that resulting from a free fall of three pounds through 3.3 feet.

(c) Bending test. Any specimen tested as special form material which is at least four inches long and at least 10 times the minimum width must undergo a special bending test: one-half of the material is struck with a steel billet with the force equivalent to a free vertical fall of three pounds through 3.3 feet.

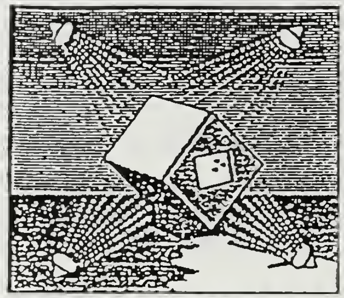
(d) Heat test. The specimen shall be heated in air to 1,472 degrees Fahrenheit, held at that temperature for 10 minutes, and then allowed to cool.

(e) Leaching assessment. Depending upon the form of the specimen (e.g., indispersible solid material or encapsulated material), the specimen must also undergo certain water immersion tests ranging from immersion for four hours to seven days.

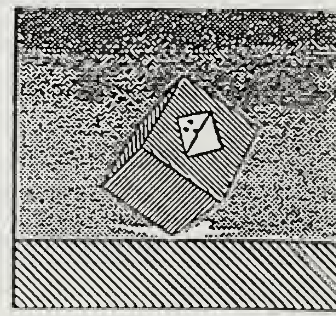
"Normal form" radioactive material is that material which does not qualify as "special form" material. Transportation requirements for normal form material are **more stringent** than those for special form material.

DOT regulations for liquids require that the package holding the liquid must contain enough absorbent material to absorb twice the volume of the liquid being shipped. [Part 173.412] This requirement is consistent with that of the NRC's packaging-for-disposal regulation. [10 CFR 61.56 (a)(2)] NRC disposal standards also require that solid waste containing liquid be packaged with as little free-standing and noncorrosive liquid as is "reasonably achievable, but in no case shall the liquid exceed 1% of the volume" [Part 61.56 (a)(3)] or 0.5% of the volume for waste processed to a stable form. [Part 61.56(B)(2)]

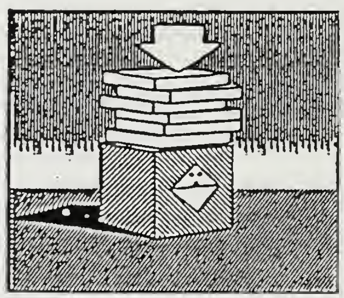
Figure 9-B
Basic Tests for Type A Packages



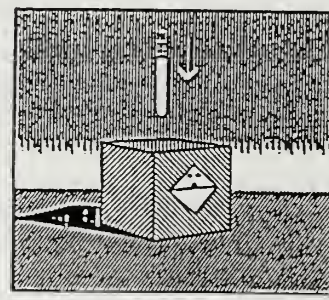
1. Water Spray test for 1 hour (to simulate rainfall of 2 inches per hour).



2. Free-fall drop test onto a flat, hard surface (a 4-foot drop if the package weighs 11,000 pounds orless).



3. Compression test of 5 times the weight of the package for at least 24 hours, and



4. Penetration test by dropping a 13-pound bar (1-1/4 inch diameter) vertically onto the package from a height of 3.3 feet.

Note: These drawings depict the basic test procedures required by regulation. These four tests are conducted in sequence. A complete description of Type A test requirements is contained in 49 CFR 173.465.

Source: U.S. Department of Energy Transporting Radioactive Material, DOE/OP-0064, Washington, D.C., August, 1989.

Packaging Types[15]

An empty shipping container for LLRW is called "packaging;" a container full of LLRW is called a "package." There are three basic packaging types prescribed by DOT and NRC for radioactive materials and LLRW transport. Each packaging type is designed so that the number of curies of any specific radionuclide allowable in a given container is limited by the degree of safety built into the container.

The basic packaging types are "Type A," "Type B," and "strong tight containers." The designation of Type A and B containers for shipping purposes bears no correlation to the NRC Class A, B, and C classification for disposal of radioactive waste.

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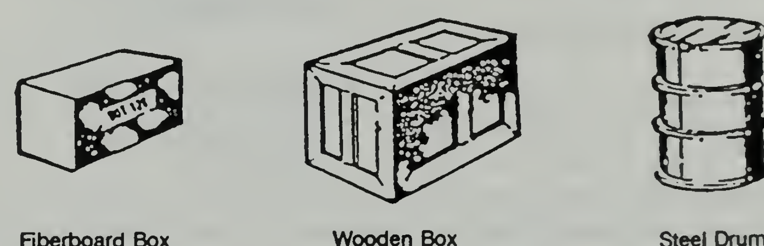
[15] The discussion of package types and certain other portions of this chapter is taken from a report of the Massachusetts Special Legislative Commission on Low-Level Radioactive Waste entitled, The Transportation of Radioactive Materials. Boston, MA, December, 1986.

DOT established the current classification system in 1983. Before that time, the level of protective packaging required was based upon the potential health threat presented by any given radionuclide if inhaled or ingested. The revised standards now also take into account the potential effect of radiation doses to the skin.

In addition to being designated by form (e.g., special form or normal form), each radionuclide is also assigned an A_1 and an A_2 value. These values, which are listed in a table in the DOT regulations [49 CFR 173.435], are determined considering such variables as radiotoxicity, intensity, penetrating power, and longevity of each radionuclide to achieve equivalent levels of protection of public health and safety. The A_1 value is the number of curies for a particular radionuclide when it is in special form; the A_2 value is the number of curies of the radionuclide in normal form. Curie limits for radionuclides that must be shipped in Type B and strong tight containers are derived from the A_1 and A_2 table.

Figure 9-C
Typical Type A Packaging

Package must withstand normal conditions (49 CFR 173.465) of transport only without loss or dispersal of the radioactive contents.



Source: U.S. Department of Transportation.

After the type, quantity, form and A_1 and A_2 values for a radionuclide are determined, the type of packaging for shipment can be identified.

Type A packaging is designed to retain their shielding and containment properties under normal conditions of transport. Type A packaging must meet certain performance objectives [49 CFR 173.465] which are illustrated in Figure 9-B. Additional tests are also required for Type A packaging designed for liquids and gases. Examples of Type A packaging are shown in Figure 9-C. Most of the LLRW shipped in Massachusetts is packaged in Type A containers, which generally take the form of 30- or 55-gallon steel drums with heavy duty closure devices.

A very small percentage of the LLRW shipped in Massachusetts qualifies under the A_1 values as special form radioactive material. Sealed radiation sources used for cancer therapy are one example of a source that can be packaged according to its A_1 value, because the radioactivity is self-contained.

In general, the number of curies of special form material allowed in a Type A container is higher than the number of curies allowed for the same radionuclides valued as A_2 or normal form material. For example, up to 10 curies of a sealed Radium-226 source used for cancer therapy could be shipped as special form (A_1), while only 0.05 curies of Radium-226 may be shipped in normal form (A_2). Most radioactive material and most LLRW is transported based on the A_2 values.

Type B packaging must meet all the performance objectives of Type A packaging, and, in addition, must withstand both DOT and NRC accident damage test conditions. These conditions are illustrated in Figure 9-D.

In addition, Type B packaging must have engineered provisions so that decay heat from higher activity contents is safely dissipated without any significant increase in surface radiation on the container or external surface of the transport vehicle. If the Type B packaging contains certain radionuclides (generally

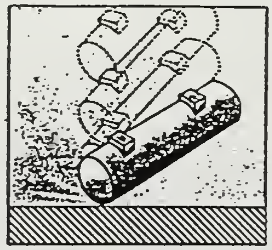
irradiated fuel and other high-activity wastes produced by nuclear power plants), the governor of each state through which such a shipment travels must be notified seven days in advance under a requirement of the NRC's transportation regulations governing fissile materials and high curie content packages. [10 CFR 71.97]

Less than one percent of Massachusetts LLRW requires Type B packaging. Some examples of this container type are shown in Figure 9-E.

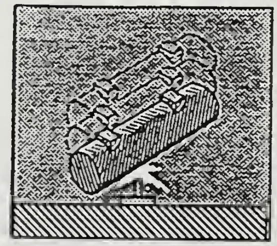
Strong Tight Containers

Much of Massachusetts LLRW is "low specific activity" (LSA) waste, and under certain conditions, can be shipped in strong tight containers. Low specific activity waste is radioactive material throughout which the radioactivity is uniformly distributed. In order to be considered low specific activity, the average concentration of radioactivity per gram of material cannot exceed:

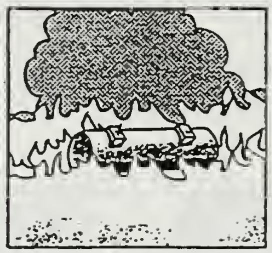
Figure 9-D
Basic Tests for Type B packages



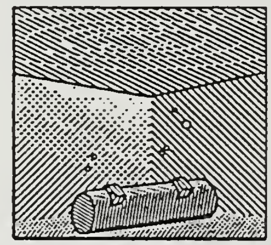
1. A 30-foot drop onto a flat, unyielding surface so that the package's weakest point is struck,



2. A 40-inch free drop onto a 6-inch-diameter steel rod at least 8 inches long, striking the package at its most vulnerable spot,



3. Exposure of the entire package to 1475 degrees for 30 minutes, and



4. For fissile materials only, immersion of the package under 3 feet of water for at least 8 hours. For all packages, a separate package is immersed under 50 feet of water for at least 8 hours.

Note: These drawings depict the basic test procedures required by regulation. These four tests are conducted in sequence. A complete description of Type B test requirements is contained 49 CFR 173.465.

Source: U.S. Department of Energy Transporting Radioactive Material, DOE/OP-0064, Washington, D.C., August, 1989.

(1) 0.0001 millicuries per gram, of radionuclides for which the A_2 quantity is not more than 0.05 curies;

(2) 0.005 millicuries per gram, of radionuclides for which the A_2 quantity is more than 0.05 curies but not greater than one curie; or

(3) 0.3 millicuries per gram, of radionuclides for which the A_2 quantity is more than one curie. [49 CFR 173.403(n)(4)]

LSA waste can also be uranium or thorium ores and their physical or chemical concentrates; unirradiated natural or depleted uranium or unirradiated natural thorium, and tritium oxide in certain low-concentration aqueous solutions. [49 CFR 173.403(n)(1), (2) and (3)]

Low specific activity LLRW can be shipped in strong tight containers if these containers will not leak under normal transportation conditions, and if there is no removable surface contamination on these

packages.

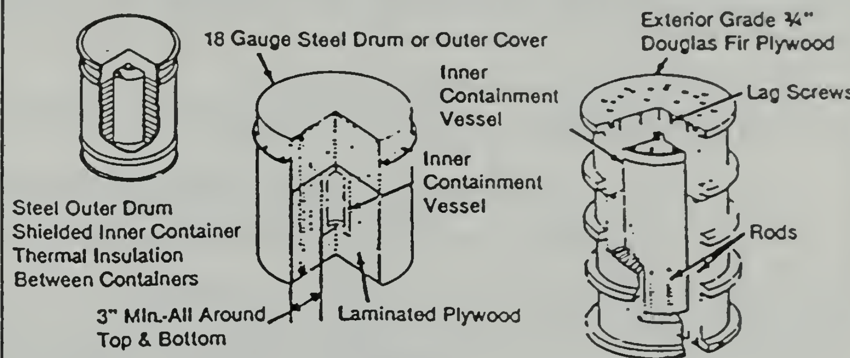
Packaging for Other Hazardous Properties

Because some radioactive materials and LLRW contain hazardous chemical properties in addition to their radiological properties, DOT regulations require certain processes to protect from these hazards.

Liquid wastes which could leak out of a steel drum, or wastes which could corrode the container, are solidified in concrete or absorbed by a diatomaceous earth compound similar to that used to clean up oil spills. The absorbent chosen must not, itself, combine with the waste to cause the package to corrode.

Figure 9-E
Typical Type B Packaging

Package must withstand both normal (49 CFR 173.465) and accident (10 CFR Part 71) test conditions without loss of contents.



Source: U.S. Department of Transportation.

Plastic liners are often used inside drums to provide an additional leakage barrier, and the drums may be packed inside larger drums or "overpacks." Because the dose of radiation that may be absorbed diminishes over distance and with each additional barrier, overpacks significantly reduce the level of surface radiation on the outside of a package.

DOT Objective 2: Operational Standards for Proper Handling and Safe Transport

The second of the three major objectives of the DOT transportation regulations is to ensure that operational standards provide proper handling and safe transport of radioactive materials and LLRW.

The major operational standards within the regulations include radiation levels for transport, labeling packages, placarding vehicles, shipping manifests, highway route controlled quantity shipments, limited quantity shipments, storage in connection with transportation, quality control prior to shipping, and vehicular safety.

Radiation Levels for Transport

DOT regulations limit the amount of radiation emitted from packages during shipment. The regulations require that the highest exposure rate 3.3 feet from the package surface be measured and written on the package label to warn drivers and package handlers how to handle the packages (e.g., shielding, remote handling, etc.). This exposure rate is known as the "transport index." Table 9-1 gives radiation limits for packages and shipment types, such as closed vans and open flatbed trucks.

Labeling Packages for Shipment

Every package of radioactive material and waste must be labeled on two opposite sides with a

Table 9-1
Radiation Limits for Packages and Shipments

Radiation levels shall not exceed the following limits in non-exclusive use shipments:

a. 200 millirem per hour at any point on the external surface of the package, and

b. 10 millirem per hour at 3.3 feet (one meter) from the package surface (e.g., transport index not to exceed 10)

Shipments in vehicles used **exclusively** for radioactive materials or waste in which the package(s) are secured in a fixed position, and no loading or unloading occurs between the beginning and end of the transportation, shall not exceed the following limits:

a. 1,000 millirem per hour on the package surface

b. 200 millirem per hour at the external surface of the vehicle

c. 10 millirem per hour at 6.6 feet (two meters) from the external surface of the vehicle

d. 2 millirem per hour in any occupied part of the vehicle such as the cab of a truck

Source: U.S. Department of Transportation. 49 CFR 173.441(a) and (b).

distinctive warning label. The labels are either Radioactive White-I, Radioactive Yellow-II or Radioactive Yellow-III.

Markings on these three label types include vertical stripes which indicate the radiation level outside the package. Labels with two or three vertical stripes (the yellow labels) have higher levels of radiation on the package surface than those with one vertical stripe (white label).

Every label must contain the name and number of curies of each radionuclide in the container, the transport index, and whether the package is Type A or Type B. If the waste contains any hazardous chemicals or exhibits the properties of hazardous chemicals, such as flammability, that label must include such information affixed to the container.

The only radioactive packages exempt from full labeling requirements of the DOT regulations are low specific activity packages. These packages must be stamped "Radioactive LSA." [49 CFR 172.392]

Figure 9-F shows examples of DOT's warning labels.

Placarding the Transporting Vehicles

In addition to the labeling of individual packages, vehicles transporting certain shipments of radioactive materials and LLRW must be placarded to comply with DOT requirements. Placarding is required for low specific activity shipments, highway route controlled quantity shipments, and all shipments containing Yellow-III labeled packages. Low specific activity shipment vehicles must be placarded because they do not have to meet the stricter packaging requirements for Type A and Type B packaging. Yellow-III packages must be placarded because they emit the highest allowable level of surface radiation.

Shipping Papers, "Uniform Manifest"

All radioactive materials and waste shipments must be inventoried and accompanied with shipping

papers. These papers, which must remain in the cab and be accessible to the driver at all times, facilitate the location of a shipment and the identification of its contents en route to its destination, as well as after its arrival.

DOT requires the following information on shipping papers:

- the name of each radionuclide in the shipment;
- the physical and chemical form of each radionuclide;
- the number of curies in each package;
- the label category (Radioactive White-I, Yellow-II or Yellow-III); and
- a notation if the shipment contains any fissile class material or waste. (See footnote 12) [49 CFR 172.203]

Figure 9-F
DOT Package Warning Labels

Source: U.S. Department of Transportation

In addition to the DOT regulations for tracking each shipment of radioactive materials and LLRW, the NRC sets requirements for any waste shipped <u>for disposal</u>. If the radioactive material is still useful or valuable, it is not considered LLRW, and therefore is not subject to these requirements. The radioactive materials licensee makes the determination as to whether an object is a "material" or an LLRW.

NRC regulation requires a "shipment manifest" for LLRW transport to a disposal facility to contain a significantly larger list of information than that of DOT:

- the name, address, and telephone number of the waste generator;
- the name, address, and telephone number (or the name and EPA hazardous waste identification number) of the person transporting the waste;
- a physical description of the waste in the shipment;
- the volume of waste;
- the name and quantity of each radionuclide in the shipment;
- the total radioactivity (curie content);
- the principal chemical form;
- wastes must be identified as either Class A, B or C, as required by the NRC in its classification system for LLRW disposal, 10 CFR Part 61.55;
- the total quantity of Hydrogen-3 (tritium), Carbon-14, Technetium-99, and Iodine-129 must be listed; and

- the name of any solidification agent used on the packaged waste; waste containing more than 0.1% chelating agents[16] by weight must be identified and the weight percentage of the chelating agent estimated;

- a certification by the waste generator that the shipped materials are properly classified, described, packaged, marked, and labeled, and are in proper condition for shipment according to the DOT regulations. [10 CFR 20.311]

The manifest requirements of 10 CFR 20.311 are designed to include all the requirements of the DOT shipping papers and any "cradle-to-grave" tracking standards of EPA's regulations under RCRA and CERCLA. However, because individual generators, brokers, processors, disposal sites, and states have developed their own formats for shipping papers, no two are exactly the same.

Uniform Manifest

In 1985, the Western Governor's Association issued a report recommending a single manifest system, called the "uniform manifest," which could be required by NRC and DOT for use by all parties involved in LLRW transportation, storage, treatment, and disposal. The 1985 report noted that the additional number of management and disposal facilities that will likely result due to state actions to fulfill requirements of federal law "increases the possibility that additional companies will become involved in facility operation. Under the existing NRC regulations, the number of different manifest forms would increase with each new facility operator, data storage would become more decentralized, and data access would become more complicated."[17]

Encouraged by state officials responsible for LLRW management, the NRC included a uniform manifest requirement in a recently-published proposal requiring computerized systems for LLRW shipment record-keeping and reporting. The final rule is expected to be published in the Federal Register in April, 1994.

Most users of radioactive materials who produce LLRW do not produce enough waste themselves to comprise a shipment. Therefore, they contract with a waste broker who collects waste from a number of generators for shipment to storage, treatment, and disposal facilities. If a shipment of waste changes hands from broker to processor, a new set of shipping papers and manifests must be added to the prior shipping record. This ensures that the exact nature of the package contents, and all parties responsible for shipping, packaging, and handling are accounted for at every step along the shipment's journey.

Highway Route Controlled Quantity Shipments

Shipments that exceed the normal curie and form limitations for Type B containers are designated as "highway route controlled quantities" and are subject to more restrictions than standard curie or surface radiation limits. In order to be designated as a highway route controlled quantity shipment, a quantity within

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[16] Chelating agents are materials that react with metal ions in waste to make the metals less reactive, or more stable in solution. Chelating agents are used in various waste treatment activities, but are a concern to the NRC because the existing disposal facilities are shallow land burial operations where chelated waste material may travel quickly through the soil and enter the groundwater.

[17] Report of the Western Governor's Association. Recommendations for Developing and Implementing a Low-Level Waste Information System Linked to a Uniform Manifest System. Department of Energy, March, 1985.

a single package must be:

(1) 3,000 times the A_1 value of the radionuclides of special form radioactive material;

(2) 3,000 times the A_2 value of the radionuclides of normal form radioactive material, or

(3) 30,000 curies, whichever is least.

Highway route controlled quantity shipments can only travel on interstate highways, which are generally the safest routes available. The DOT regulations allow a state to designate "preferred routes" if the interstate highway is not evaluated as the route of least radioactive risk. The Massachusetts Department of Highways has adopted the DOT interstate highway standard, and therefore highway route controlled quantity shipments use only the interstate network in the Commonwealth.

Companies shipping highway route controlled quantities must file route plans with the DOT a week before the shipment gets under way, and drivers of these shipments must receive special training. Highway route controlled shipments are packaged in Type B containers and transported in "exclusive use" vehicles. Not all Type B packages, however, are highway route controlled quantity packages.

Most radioactive materials users will never generate a single shipment with a curie content high enough to be considered a highway route controlled quantity (although every few years, a nuclear power plant may generate such a shipment, due to the replacement of an activated reactor component). There has not been a highway route controlled quantity shipment originating in Massachusetts since 1983, when the old "large quantity" shipments were renamed highway route controlled quantities. Generators usually divide their waste into smaller shipments to avoid the highway route controlled quantity requirements. However, the two Massachusetts nuclear power plants are storing in their plants' spent fuel pools some wastes which could comprise such shipments.

Limited Quantity Shipments

DOT regulations also allow shipments of very low specific activity (LSA) materials and LLRW in strong tight containers to be transported in non-exclusive use vehicles. These materials are classified by the DOT as "limited quantity" shipments, and are subject to regulations that are slightly less strict than for standard Type A shipments. They are exempt from certain packaging, marking and labeling requirements, but must be marked "Radioactive -- LSA" on the package exterior. [49 CFR 173.425]

Storage Incident to Transportation

To ensure the safety of transportation workers, DOT requires non-NRC or state-licensed storage areas (such as rail transit areas, terminal buildings, storerooms, or assembly yards) to comply with regulations limiting the number of radioactive packages in a specific storage area. The number of packages bearing Radioactive Yellow-II or Radioactive Yellow-III labels must be limited so that the sum of their transport indexes does not exceed 50. Since the transport index (i.e., a number expressing the maximum radiation level in millirem per hour at 3.3 feet from the external surface of the package), of any individual package cannot be greater than 10, this rule prohibits more than five packages containing radioactive materials or LLRW at the maximum radioactive quantities from storage areas en route to a given destination.

Quality Control Prior to Shipment

Before each shipment of any radioactive material or LLRW, DOT regulations [49 CFR 173.475] require the shipper to examine or test the package to ensure that it meets numerous standards, including

whether or not the package is in an "unimpaired" physical condition, has a defect-free closure device, and the external radiation and contamination levels are within allowable limits.

Vehicle Safety

In addition to the "quality control" inspection given to each package before shipment, every vehicle used to transport LLRW must be given a safety inspection before embarking on a trip. This inspection, required by 49 CFR Part 393 of the DOT rules, includes checks of tires, brakes, headlights, reflectors, mirrors, and vehicle frame.

DOT Objective 3: Enforcement Procedures

The third and final major objective of the DOT regulations is provision for adequate enforcement procedures to ensure safety during transport.

The problems of inadequate federal enforcement during the mid-to-late 1970s led to a casual attitude about shipping requirements among some LLRW generators, and resulted in an increase in transportation violations. This lack of enforcement was identified earlier in this chapter as a major reason why the governors of the states of South Carolina, Nevada, and Washington sought passage of the Low-Level Radioactive Waste Policy Act of 1980.

Since that time, enforcement efforts have increased. Federal enforcement requirements include periodic inspections of packages and equipment, reviews of transport personnel, audits of shipping papers and other transportation records, and performance evaluations. The NRC may fine or suspend licenses of radioactive materials licensees who violate transportation regulations [10 CFR 30.61(b)], and must notify a licensee of license revocation or suspension unless the violation is "willful," ["Part" 30.61(c)] in which case no notification is required.

9.5 Federal Pre-emption of State and Local Regulations

The previous section describes the various DOT and NRC requirements pertaining to LLRW (and radioactive materials) shipments. These regulations include packaging standards, operational standards (handling and safe transportation), and enforcement procedures that must be followed by radioactive materials licensees who transport materials and LLRW, by shipping companies that transport these materials, and by brokers and processors who handle and treat LLRW.

The 1990 amendments to the federal hazardous materials transportation law of 1975 clarify a dispute over the pre-emption issue that has existed since the adoption of the 1975 law. Prior to passage of the amendments, states and localities could enact different regulations if they received a waiver from the DOT Secretary after a determination that the state or local requirement:

(1) offers public protection equal to or greater than the federal law and DOT's regulations, and

(2) is not unreasonably burdensome to interstate commerce.

However, in order to apply for a waiver, a state or local government had to admit that its requirement may indeed be inconsistent with federal law. Because of this rule, states and localities often chose instead to argue that their requirements were not inconsistent, and let the courts decide.

The new federal law clearly delineates that the DOT and other federal agencies have pre-emptive authority on nearly all transportation issues. The new pre-emption standards declare that non-federal requirements in certain subject areas must be "substantially the same as" federal regulations. In its proposed regulations, DOT has defined "substantially the same" as "conforming in every significant aspect."

DOT "Routing" Rule

The issue of federal pre-emption came to a head in the late 1970s when the DOT adopted regulations to pre-empt most local prohibitions on the shipment of radioactive materials and waste. The regulation, known as HM-164, provides that a state or local rule regulating the routes a shipment may follow is inconsistent if it prohibits highway transportation between any two points without providing an alternate route.

The DOT routing regulation was developed in response to several hundred local transportation bans, including one adopted by New York City officials in 1976. The New York City ordinance prohibited the shipment of certain radioactive materials in or through the city. DOT reviewed the New York City rule, and could not find any contradiction between it and any provision of the federal HMTA or DOT's regulations. However, because DOT felt the city ordinance would seriously impact radioactive materials commerce within the city (not interstate commerce), DOT promulgated its HM-164 routing rule.

In issuing this routing regulation, DOT stated there are "serious problems from both a practical and safety standpoint associated with placing ultimate routing authority with each of the 23,000 local jurisdictions in the country."[18] DOT cited the probability that multiple local bans and restrictions would force shipments to travel circuitous routes over roads less safe and less accessible to emergency response action than a designated highway. In place of "piecemeal" transportation regulation, DOT issued two routing rules that allow for adjustments to specific conditions in any locality.

These two rules are:

(1) General route. This rule requires the shipping company to choose "routes which minimize radiological risk," and to "consider available information on accident rates, transit, time, population density and activities, time of day, and day of week during which transportation will occur." [49 CFR 177.825(a)]

This general routing rule does not have to be followed when there is only one "practicable" highway route available for safety purposes or when the package has been designated a highway route controlled quantity.

(2) Preferred route. For highway route controlled quantity shipments, the routing rule specifies that such shipments be limited to interstate roads or preferred routes. Generally, interstate highways are the preferred routes for radioactive waste transport. Interstate highways tend to be maintained, have lower accident rates, are accessible to emergency vehicles, and can help lower the time a shipment is on the road. DOT regulations allow each state to designate "preferred routes," as has been done by the Massachusetts Department of Highways.

DOT's routing regulations also specify a number of general circumstances in which a state or local routing rule would be inconsistent. [49 CFR Part 177, Appendix A] Such rules would be pre-empted if they:

- conflict with physical security requirements of the NRC [10 CFR Part 73], and certain shipping

[18] U.S. Department of Transportation. Federal Register, Monday, Jan. 19, 1981, Volume 46, No. 12, p. 5301.

requirements relating to highway route controlled quantity packages;

- require additional or special personnel, equipment or escorts;
- require additional or different shipping paper entries, placards or other hazard warning devices;
- require filing route plans or other documents containing information that is specific to individual shipments;
- require prenotification;
- require accident or incident reporting other than as immediately necessary for emergency assistance; or
- unnecessarily delay transportation.

Besides routing laws, state and local governments have established requirements on other areas of radioactive materials and waste transportation. These areas include:

- permit requirements;
- prenotification;
- prohibitions on hours of travel;
- accident notice requirements;
- required use of headlights; and
- required inspections.

Boston Restriction Pre-Empted

An ordinance adopted by the City of Boston regulating all hazardous materials shipments through the city (not just radioactive materials and waste) was declared inconsistent by the DOT in 1981. Boston's rule would have required that companies shipping hazardous materials obtain special permits and observe routing restrictions and a ban on rush-hour transport. The rule also would have required 24-hour headlight use and vehicle placarding in addition to those required by the DOT.

Challenges to DOT Consistency

If not pre-empted by DOT, a state or local rule is generally ruled inconsistent only if it is challenged by a radioactive materials licensee or a shipping company. For example, Vermont adopted a requirement for highway route controlled shipments that included seven-day prenotification, a three-car escort, and a $1,000 dollar fee per shipment. This rule was pre-empted by DOT after being challenged by a high-level radioactive materials broker.

In contrast, the State of Connecticut worked with its utilities and shipping companies to devise an agreeable program for prenotification and permitting of all placarded or nuclear fuel cycle shipments. Because there was no challenge to the new rules, they were not pre-empted by DOT. The program has enabled Connecticut to gather information necessary for spot inspection and emergency response activities,

without causing any potentially-threatening transportation delays or impediments.

Other state and local requirements, which have not been challenged, affect shipments moving through Massachusetts. For example, Connecticut prohibits the overnight transportation of radioactive material, which forces shipments of highly radioactive wastes to park overnight on the Massachusetts border, or use alternative, circuitous routes. Rhode Island bans shipments during morning and evening rush hours, also delaying shipments on the Massachusetts border. Certain towns in Vermont prohibit radioactive materials and waste transport, and shippers accommodate these restrictions by following routes that meander back and forth across the Vermont-Massachusetts border.

Power Plant Shipments

In 1980, DPH and the nuclear power plants in Massachusetts, Vermont, Maine, and Connecticut entered into an informal, voluntary agreement with Berkshire County to notify the Berkshire County Fire Radio Network of any power plant shipments (not just LLRW) through that county. This prenotification program provides 24-hour notice to towns in Berkshire County to better prepare local emergency personnel.

9.6 Keeping Track of Transportation Events

As was noted in section 9.1 of this chapter, a national database incident and accident reporting system has been established to aid enforcement activities. All transportation event reports back to 1971 were incorporated into the system.[19]

Reports are filed from information supplied by DOT, NRC, state radiation control offices, the DOE "Unusual Occurrence Report" system, media coverage of an event, and the DOE Emergency Response Assistance Teams.[20]

DOT regulations [49 CFR 171.15] require that a report be filed after any occurrence during the course of handling, loading, transporting, unloading, or temporary storage (in transit) of radioactive materials or waste if any of the following results:

(1) an individual dies;

(2) an individual is injured and requires hospitalization;

(3) damage to the transport vehicle or other property exceeds $50,000;

(4) fire, breakage, spillage, or suspected contamination of radioactive materials occurs, or

(5) any other event occurs that the transport company believes should be reported.

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[19] According to the database manager of this reporting system, accidents and incidents may not be reported rapidly by the DOT. In addition, some data may be reclassified (upgraded as an accident or incident, or down graded as a non-event) after the initial report.

[20] The Massachusetts Emergency Response Assistance Team is known as NIAT, the Nuclear Incident Advisory Team. It is described in detail in Section 9.7 of this chapter.

The NRC requires reporting if radioactive materials or wastes are lost or stolen, a radiation exposure occurs, or radioactivity is released from a package. Reporting requirements include:

- "immediate" reporting to the NRC by telephone if a loss or theft has occurred if the quantity of radioactive material or LLRW, or the circumstance is such, that a "substantial hazard" may result to persons in unrestricted areas, and

- written notification within 30 days, including the names of any individuals who may have been exposed to radiation. [10 CFR 20.402]

"Immediate" notification is required in the case of any transportation event which may have caused, or threatens to cause:

(1) exposure of the whole body of any individual to 25 rems[21] or more of radiation; exposure to the skin of 150 rems or more; or exposure of the feet, ankles, hands, or forearms to 375 rems or more of radiation; or

(2) the release of radioactive material or waste in concentrations which, averaged over a 24-hour period, would exceed 5,000 times the limits for each radionuclide allowed in the NRC's regulatory tables; or

(3) the loss of one work week or more of operation; or

(4) property damage in excess of $200,000. [10 CFR 20.403(a)]

In addition, the NRC requires notification within 24 hours (as distinguished from "immediate") if the transportation event may have caused or threatens to cause:

(1) exposure of the whole body to 5 rems; of the skin to 30 rems; or of the feet, ankles, hands or forearms to 75 rems; or

(2) the release of radioactive waste in concentrations which, averaged over a 24-hour period, would exceed 500 times the allowable limits established in the NRC's regulatory tables; or

(3) a loss of one day or more of a licensee's operations; or

(4) property damage in excess of $2,000. [10 CFR 20.403(b)]

Improved Enforcement has Reduced Violations

Tightened enforcement activities have resulted in greater compliance with transportation regulations designed to protect public health. In states that operate disposal sites, the ability of the site operators to inspect every shipment, and impose fines or reject a shipment, has helped to greatly improve shipping practices.

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[21] A "rem" is a measure of the dose of any ionizing radiation to body tissues in terms of its estimated biological effect. "Whole body" dose is to be interpreted to mean "effective dose equivalent" wherever it appears in this Plan. The former term is used in many regulations and documents cited in the Plan, and is retained in the text for consistency with these documents. The latter term represents recent changes in expressing dose.

As noted earlier in this chapter, only 54 transportation accidents have occurred involving LLRW since 1971, out of approximately 2 million radioactive materials and waste shipments that occur annually in the United States. Only five of these 54 involved the release of LLRW. Table 9-2 provides a yearly breakdown of LLRW transportation accidents for the period 1971 through 1991, and identifies the state where each accident occurred. None of the accidents were in Massachusetts. Appendix 9A briefly describes each of these accidents, involving LLRW shipments but no release of radiation.

Table 9-2
Transportation Accidents Involving LLRW Shipments Where No Release Occurred
(See details in Appendix 9A)

1971 - 0
1972 - 0
1973 - 1 [South Carolina[2]]
1974 - 3 [Montana, Ohio, Kentucky[2]]
1975 - 3 [South Carolina,[2] Washington, DC, West Virginia]
1976 - 3 [New York, Connecticut, South Carolina[2]]
1977 - 2 [South Carolina,[2] North Carolina]6
1978 - 5 [Virginia, South Carolina,[2] Tennessee, Missouri, Wisconsin]
1979 - 6 [Tennessee, Missouri, South Carolina (2),[2] Montana (2)]
1980 - 7 [New York, North Carolina, Arizona, Ohio, Pennsylvania, Montana, New Jersey]
1981 - 3 [South Carolina (2),[2] Colorado]
1982 - 4 [Idaho, Utah, South Carolina,[2] North Dakota]
1983 - 4 [Illinois, New York, West Virginia, Idaho]
1984 - 2 [Illinois, Wyoming]
1985 - 2 [New York, Pennsylvania]
1986 - 2 [Washington,[2] New York]
1987 - 1 [Iowa]
1988 - 0
1989 - 1 [Montana]
1990 - 0
1991 - 0
1992 - 0
1993 - 0

[1] A "transportation accident" is a transport event ranging from a minor accident to a major collision that involves the vehicle transporting radioactive material or waste.
[2] The states referenced by this footnote were the sites of the LLRW disposal facilities where the vehicles were heading when these accidents occurred.

Source: Sandia National Laboratories. Radioactive Material Incident Report. Albuquerque, New Mexico, 1993.

The five transportation "incidents" on record since 1971 in which radiation was released are summarized as follows:

(1) January 12, 1976. A tractor trailer transporting an LLRW shipment to the Maxey Flats, Kentucky, disposal site was traveling on I-64 west of Catlettsburg, Kentucky, when it struck a state highway truck spreading salt on icy roads. Twelve drums containing radioactive concrete and metal broke through the trailer, hit the cab, and fell off the truck. Eight of the drums ruptured when they hit the highway. Responding to the accident were Kentucky's State Police, Department of Human Resources, and Civil Defense. They determined that no radiological hazard had occurred, since radiation levels were not above normal background levels. The waste was repackaged into new drums, and sent to the disposal site.

(2) November 27, 1987. A tractor-trailer was traveling on I-80 near Cheyenne, Wyoming, with a shipment of radioactive hoses, metal parts, and radium-contaminated soil heading for the Hanford, Washington, disposal site. Weather and driver error resulted in the truck overturning, causing five of the six metal boxes in the load to fall onto the road and spill a portion of their contents. Responders included Wyoming's State Police, Radiological Health Services and Highway Department. Radiological surveys determined that the radiation released was not above normal background level. The waste was re-packaged and returned to its place of origin in Tennessee.

(3) December 31, 1987. A tractor-trailer en route to the Hanford, Washington, disposal site was involved

in a traffic collision in Richland, Washington, the community adjacent to the disposal site. Five of six metal boxes opened, and solid LLRW was released onto the road. Responding to the incident were the Richland Police and Fire departments, DOE (which owns the entire federal Hanford Reservation where the LLRW disposal facility is located), U.S. Ecology (the LLRW disposal site operator), Hanford Security personnel, and the Washington Department of Social and Health Services. Surveys indicated that no radioactivity above normal background levels was present, after the waste was repackaged.

(4) October 24, 1989. A flatbed trailer truck traveling on U.S. Highway 460 in Christiansburg, Virginia, on its way to Barnwell, South Carolina, overturned when the driver made a sharp left turn. Four metal boxes containing 384 cubic feet of uranium oxide-contaminated soil fell of the flatbed trailer, and ruptured. Christiansburg fire and police, and the Virginia State Health Department responded. The soil was repackaged, and radiological surveys determined that no above-normal level of radiation was present.

(5) March 26, 1991. The Burlington Northern Railroad Company was transporting a rail car containing a Type B cask from the Nine Mile Point nuclear power plant in New York to the LLRW disposal site in Hanford, Washington. When the cask arrived at Hanford, it was determined to have been damaged during transit, and radioactivity was detected above DOT limits on the sides of the cask.

These accidents and incidents involving LLRW can be compared to the accidents involving releases of non-radioactive hazardous material, some of which have resulted in injuries and death, according to the DOT. In 1990 alone, 287 such incidents occurred, of which 103 involved the release of flammable-combustible liquids, 65 involved combustible liquids, and 43 involved corrosive materials. The remainder involved the release of explosives, poisonous materials, flammable gas, nonflammable compressed gas, and oxidizers.

An accident in western Massachusetts in 1991 involving unirradiated nuclear fuel assemblies is not an LLRW-related accident, because it involved nuclear materials, not LLRW. The accident involved the shipment of 12 containers, each containing two unirradiated nuclear fuel assemblies en route to the Vermont Yankee nuclear-powered electric generating plant in Vernon, Vermont.

The accident occurred on Dec. 16, 1991, at 3:15 a.m. on Interstate 91 in downtown Springfield. The driver of the truck transporting the fuel assemblies swerved to avoid a collision with a car traveling on the wrong side of the interstate. The car hit the truck near the right fuel tank, causing the truck to skid across the highway and hit the center guardrail. A fire started in the engine compartment of the tractor, and spread to the entire tractor and trailer. NRC's accident report indicated that the fire burned for approximately three hours. Because the fire was not extinguished, the flatbed trailer was completely destroyed.

As a result, eight containers fell off the burned trailer, sustaining minor damage. The wooden outer packaging was burned, and the inner metal containers holding the unirradiated fuel assemblies sustained some damage; however the assemblies themselves were not damaged. The cargo was returned to its manufacturer for repair of the packaging.

9.7 Emergency Preparedness and Response

Statistics presented in this chapter have documented the extremely good transportation accident and incident record of LLRW shipments. However, because there is some public health and environmental risk involved in the transportation of LLRW, even if it is exceedingly small, emergency preparedness and response activities are an important component of LLRW management.

During the mid-1970s, the NRC and DOT developed emergency preparedness guidance to help states and municipalities develop emergency response plans. The NRC surveyed each state's ability to respond to radiological transportation incidents, and, in cooperation with the Environmental Protection Agency, developed a model state emergency response plan. The DOT prepared guidance for local emergency response training programs.

In December, 1975, DOT and NRC published a joint responsibilities agreement [40 Federal Register 59484] in preparation for developing a new planning guidance document to assist states. Subsequently, the Federal Emergency Management Agency (FEMA) assumed responsibility under a Presidential Order to coordinate all federal off-site nuclear emergency planning and response functions. In 1980, FEMA assigned responsibilities to each Involved federal agency to assure a coordinated means of assisting states and local governments in emergency planning and preparedness.

As part of this federal cooperative effort, a Federal Radiological Preparedness Coordinating Committee was established, and is chaired by FEMA. A subcommittee of this group, the Subcommittee on Transportation Accidents, is comprised of representatives of FEMA, DOT, NRC, EPA, DOE, U.S. Department of Health and Human Services, Sandia National Laboratories, the Western Interstate Energy Board, and the Southern States Energy Board.

Emergency Preparedness "Guidance"

The subcommittee published a guidance document in March, 1983, which identifies eight factors associated with consequences of transportation accidents, either trivial or severe in nature. They are:

(1) severity of accident forces (crushing, fire, and impact);

(2) accident location (rural, suburban, and urban);

(3) amount and type of material being transported (radionuclides, chemical and physical characteristics);

(4) type of packaging used in the shipment (LSA, Type A, and Type B);

(5) if releases occur, the fraction of material released from the packaging;

(6) meteorological conditions at the accident site;

(7) time required for emergency response personnel to reach the site and diminish the consequences, and

(8) the presence or possibility of a fire or explosion that may act as a dispersing mechanism or interact with radioactive materials, packaging, or other transported materials.[22]

The FEMA guidance also contains 14 planning objectives for use voluntarily by states and municipalities. These objectives are summarized as follows:

(1) Assignment of responsibility. Each plan should identify federal, state, municipal, and private-

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[22] Federal Emergency Management Agency. Guidance for Developing State and Local Radiological Emergency Response Plans and Preparedness for Transportation Accidents. FEMA-REP-5, Washington, DC, March, 1983.

sector organizations or individuals that comprise the overall planning and response. The plan should ensure the capability for 24-hour emergency operations, and should assign authority and responsibility for such functions as "command and control," communications, fire, rescue, law enforcement, emergency medical services, accident assessment, and radiological exposure control.

(2) Analysis of radioactive material transportation. Information should be collected and analyzed to identify the primary routes used by major LLRW generators, and the most likely accident locations.

(3) Contiguous state and local coordination. State and local emergency response teams should identify and form mutual aid agreements with contiguous states and contiguous municipalities.

(4) Emergency equipment, facilities, and resources. Emergency response plans should identify the location and 24-hour availability of emergency equipment, and plans should identify specialized personnel from governmental entities, hospitals, universities, radioactive materials users, and professional societies who would be available to assist on an emergency basis.

(5) Notification methods and procedures. Plans should establish procedures for notifying emergency response personnel and exchanging information, and should include call lists of specific individuals to be notified in case of an emergency.

(6) Emergency communications. Plans should provide for reliable backup communications systems, 24-hour-a-day linkage to federal, state and local emergency response networks, and periodic testing of communications systems.

(7) Public information. Emergency response plans should provide for communications to the general public in order to provide accurate information for the protection of public health and property.

(8) Accident assessment. Plans should include training for radiological response teams to: determine if radioactive materials or wastes are involved; assess personal injury and provide first aid; obtain information about the type of packaging and the type, quantity, and chemical form of LLRW involved; control the accident area; and provide for environmental sampling, among other duties.

(9) Protective actions. Plans should identify methods to protect residents of an accident area, if necessary, including shelter, respiratory protection, and evacuation. Procedures should also be developed to contain any spilled radioactive material or waste, or to limit any spread of contamination.

(10) Radiation exposure control. Plans should identify procedures to protect emergency personnel and persons at the accident scene from excessive radiation exposure.

(11) Medical support. Plans should include agreements with local hospitals or other medical facilities to ensure locations for treating injured persons.

(12) Post-accident operations. Emergency response plans should include procedures for cleanup and decontamination of property, vehicles, and equipment.

(13) Radiological emergency response training. Training should be provided to individuals responsible for emergency response on such basic subjects as radiation, radioactivity, and contamination; DOT and NRC transportation regulations, and the general responsibilities of radioactive materials licensees and shippers during emergencies.

(14) Periodic review and update. Emergency response plans should be reviewed periodically, and updated as needed if major changes are appropriate.

Emergency Response in Massachusetts

The 14 objectives of the FEMA guidance have been incorporated into the planning and emergency response activities of the responsible state and local entities. The Massachusetts Emergency Management Agency (MEMA), pursuant to St. 1950 c.639, as amended, has developed, and continually reviews, emergency planning and support services.

MEMA has a local Civil Defense coordinator in each municipality, who, with the local fire department and local and state police, are generally the first respondents to an accident. They immediately contact the Nuclear Incident Advisory Team (NIAT), an arm of DPH, which coordinates emergency response, determines the hazards associated with a transportation event, and determines the necessary response actions.

DPH developed NIAT in the early 1960s in cooperation with other state agencies and the New England Chapter of the Health Physics Society. The team, which consists of a number of principal members and 32 advisors and consultants, works with federal agencies such as the NRC, Coast Guard, Army, and Environmental Protection Agency; and with state agencies including MEMA, Department of Environmental Protection (DEP), Labor and Industries, and Department of Public Safety.

In addition, NIAT also cooperates with the New England Radiological Health Compact, a regional agreement among the six New England states, which assures that reciprocal radiation emergency response is available throughout New England.

The lead NIAT contact is the director of DPH's Radiation Control Program. A NIAT handbook is available which guides participants on actions to be taken in case of an emergency. The major emphasis is on emergencies at the two nuclear powered utility plants, in Plymouth and Rowe. For all localized transportation events, the handbook instructs the consultant members of the NIAT team to use their own "judgment" in handling each situation, and to advise local and state emergency response authorities about potential or actual radiation dangers due to an accident.

Hazardous Materials Emergency Response

In addition to the NIAT emergency response procedure, state law requires a response to all hazardous materials incidents, not just those involving transportation.

The regulations developed to implement Massachusetts General Laws c.21E (Chapter 21E), the Massachusetts Oil and Hazardous Materials Release Prevention Act, enable DEP to enforce actions related to the discovery, notification, assessment of, and response to "releases and threats of release" of oil or hazardous materials, and defines hazardous materials to include both radioactive materials and waste.

Chapter 21E requires the development of a Massachusetts Contingency Plan, which identifies the roles and responsibilities of DEP, other government agencies, potentially responsible parties, other persons, and the public, as they relate to "response actions."

The statute requires that DEP be notified in the case of "releases" or "threats of releases" of radioactive materials and waste, which may require an "emergency response action" or a "remedial response action," or both.

DEP generally defers to NIAT for emergency responses of radioactive materials or waste.

9.8 Recommendations on LLRW Transportation

Two major factors will affect the transportation of LLRW shipments in Massachusetts. They are:

(1) proposed changes in NRC and DOT regulations for compatibility with the latest revisions of the International Atomic Energy Agency, and

(2) changes in current shipping routes that will occur if an LLRW disposal facility is sited and built in Massachusetts.

Proposed Rules Changes

The NRC and the DOT published proposed changes to their regulations in 1988 and 1989, respectively, in order to make their rules compatible with the 1985 revisions of the International Atomic Energy Agency (IAEA) Safety Series #6. These changes have not become final, however, due to opposition from various radioactive materials user groups, concern about the potential increases in shipments that could occur as a result, and differences between the IAEA standards and the proposed rule changes.

In February, 1993, the IAEA decided to make further changes to its Safety Series #6. Such changes will further delay implementation of the proposed new DOT and NRC changes, perhaps to as late as 1996.

A summary of the key NRC and DOT changes follows:

Changes in package design requirements. Two changes are proposed for the four existing container types (DOT Type A, NRC Type A, NRC Type B and Strong Tight Containers). First, new rules would eliminate the NRC Type A container, currently used to ship greater than Type A Low Specific Activity material. Low specific activity material or waste that exceeds the Type A limitations in the regulatory tables would be shipped in Type B packaging. Second, the Strong Tight Containers would have to meet new testing and qualification requirements greater than the existing standards.

New package categories. Three new package categories are proposed for low specific activity material or waste and for a new designation of radioactive material called Surface Contaminated Object.[23] The packaging categories are Industrial Package-1 (IP-1), Industrial Package-2 (IP-2) and Industrial Package-3 (IP-3). The industrial packaging is proposed to improve the integrity of the packaging used for the shipment of low specific activity and surface contaminated objects. These new packages would also allow the shipment of radioactive materials in international commerce with a minimum of delays.

Increasing the specific activity limits for certain "nondispersible" low specific activity (LSA) material while limiting the quantity of LSA material that may be shipped in other than a Type B package. NRC initially proposed to adopt the International Atomic Energy Agency standard that requires unshielded containers with radiation levels of one rem per hour measured at 9.9 feet to constitute a Type B shipment. However, comments to the proposed rule led NRC to conclude that it would be extremely difficult to enforce. It therefore published a revised proposal to limit radioactivity content which qualifies for shipment in a Type A package to two times the A_1 limit ($2A_1$) found in the existing regulations. Radioactivity content that exceeds this new level would require a Type B package.

Low specific activity material that is less than $2A_1$ would be shipped in an Industrial Package-3,

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[23] Surface Contaminated Object (SCO) means a solid object that is not itself radioactive but which has radioactive material distributed on any of its surfaces.

which has essentially the same requirements as the licensed NRC Type A packaging under the current regulations. The major difference is a shift of regulatory authority from NRC to DOT.

Expansion of radionuclide list; changes in limits. Another major change proposed in the new regulations is an expansion of the radionuclide list in 49 CFR 173.435 from 284 to 378 entries to provide greater assurance that unlisted radionuclides will not be transported in an unregulated manner.

Changes in the limits of the current radionuclides in the table are also proposed. Of the 284 existing radionuclides listed on the table, A_1 values would be raised in 144 cases and lowered in 73. A_2 values would be raised in 129 cases and lowered in 95. Table 9-3 shows changes in the A_1 and A_2 values for selected radionuclides.

The changes proposed by the NRC and DOT are designed to ensure greater protection to the public and to transportation workers. More shipments will require Type B containers, which provide enhanced protection for radiation.

A problem for certain users of radioactive materials exists in that only six Type B casks are currently available to service all radioactive materials users nationally. With greater emphasis on Type B containers, additional Type B shipping casks will be required, increasing existing shipping costs for those who produce this type of waste. An analysis of these increased costs, done in 1989 for the Electric Power Research Institute, predicts an increased annual nuclear power industry cost of $7.8 million nationally.

Table 9-3
Proposed Changes in Radionuclide Limits

Radionuclide	Existing		Proposed	
	A^1	A^2	A^1	A^2
Co-60	7.0	7.0	10.8	10.8
Sr-90	10.0	10.8	5.4	2.7
Ni-63	1000.0	100.0	1080.0	810.0
Fe-55	1000.0	1000.0	1080.0	1080.0

Source: U.S. Department of Transportation. Transportation Regulations; Compatibility with Regulations of the International Atomic Energy Agency." Federal Register, Nov. 14, 1989.

Recommendations

As Massachusetts assumes responsibility for LLRW management pursuant to the mandates of federal law (see Chapter 1), and takes steps to ensure that LLRW is safely and environmentally managed, the impacts of radioactive shipments on the public and the LLRW-generating community will be continually evaluated.

Conditions of LLRW available for shipment. The goal of the Commonwealth's efforts will be to ensure that only shipments are made that have the highest possible prospect of arriving at their destinations safely, in a manner acceptable to the destination entity, without environmental damage and without exposing the Commonwealth to contingent liabilities. To that end, the Management Board regards LLRW to be

available for shipment only when:

(1) Prior agreement has been reached with a destination entity licensed to receive the waste;

(2) All terms of the agreement, including any waste acceptance criteria or requirement for payment of a fee, have been complied with;

(3) All regulatory requirements governing the packaging or shipment of the LLRW have been complied with; and

(4) All measures appropriate to the LLRW shipment have been taken to ensure that the waste can be received safely at its destination.

Depending upon the availability and location of disposal facilities, Massachusetts LLRW generators may travel different routes to move their waste, or make fewer trips. For example, if out-of-state disposal facilities cease to be available to all types of LLRW, Massachusetts generators will be forced to store waste on site until disposal capacity is available. On-site storage could result in fewer shipments of LLRW, although it will not affect most current shipments of radioactive "materials" being transported from one location to another.

Re-entry policy. However, many LLRW generators may decide that on-site storage would be more economical and protective of the public health and the environment if their LLRW were treated prior to being placed in storage. As is noted in Chapter 11 of this volume, treatment frequently occurs on site, where LLRW was generated. Treatment also occurs off site, and out of state. Transportation of LLRW to treatment facilities may or may not increase the number of LLRW shipments that currently occurs in the Commonwealth.[24]

If this situation occurs, that LLRW generated in Massachusetts is shipped out of state for treatment and then returned to its generator within the Commonwealth due to the unavailability of disposal facilities, the Management Board will ensure that the waste will be permitted to re-enter the state and will be returned to its owner for storage, if the following conditions are met:

(1) The Management Board has been given prior notification of the waste shipment to be returned, indicating the chemical composition, activity, and volume of the waste, the shipping destination and carrier;

(2) The generator is authorized to, and has agreed to accept the waste back within the terms of its license;

(3) The generator has executed a contract for the treatment or processing of the waste; and

(4) The waste satisfies any and all waste acceptance criteria imposed by such a contract.

Transportation effects of siting decision. A decision by the Management Board to identify a site for a centralized LLRW storage, treatment, or disposal facility in Massachusetts will also affect LLRW shipments in the state. The average length and duration of a trip from Massachusetts to the Barnwell, South Carolina, disposal site is 940 miles (three to four days). For Massachusetts generators who sent their waste to the now-inaccessible Hanford, Washington, disposal site (because certain LLRW was not accepted at Barnwell),

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[24] According to surveys conducted annually by the Management Board, 568 shipments of LLRW occurred in Massachusetts in 1990; 637 in 1991; and 612 in 1992.

the average length and duration of that trip was 2,835 miles (four to five days). Information on the annual transportation activities of Massachusetts LLRW generators can be found in the Management Board's annual LLRW survey report, generally published in the late fall of each year.

A disposal facility in or near Massachusetts will reduce the transportation costs of in-state waste producers. In addition, a facility in Massachusetts will potentially move some shipments (those containing waste) onto different highways than are currently utilized. The potential impact upon the public in some portions of the state would therefore increase.

An in-state disposal facility could result in increased disposal costs for LLRW generators, depending upon certain packaging or waste form conditions that may be imposed. For example, certain waste treatment requirements may be established to ensure that all disposable waste is stabilized prior to disposal. Such requirements could increase the movement of LLRW to in- and out-of-state processing facilities before shipment to the disposal location, thereby increasing transport costs and the duration of shipments, and altering their locations.

Emergency response "exercises." If the Commonwealth determines that an in-state LLRW storage, treatment, or disposal facility is necessary, MEMA, the State Police, DPH, and other appropriate state agencies should plan for, train, and execute LLRW shipment emergency responses. Such "exercises" will improve the technical quality of emergency response procedures, and increase public confidence in the system.

Transportation risk analysis. If such an in-state facility is initiated, estimates of the number of LLRW shipments to the facility, as well as estimates of non-radioactive traffic associated with facility operation, and traffic control planning, will minimize any potential traffic problems. These estimates will be developed during detailed characterization of candidate sites, and will utilize, to the extent possible, the transportation planning efforts of state, regional, and local planning agencies, in connection with the transportation planning requirements of the federal Intermodal Surface Transportation Efficiency Act of 1991. In addition, a recognition must be made to the public that the "average" number of LLRW shipments will most likely be lower than the "initial" shipments, necessary to reduce LLRW inventories that may be in storage for several years.

If an in-state facility siting decision is made, the Management Board will conduct an LLRW transportation risk analysis to evaluate potential radiological risks from LLRW transportation to drivers, LLRW facility employees, and the public.

Coordinate regional inspections and shipping schedules. If Massachusetts sites a regional LLRW disposal facility, the Management Board will encourage DPH to work with appropriate regulatory agencies from the states within the region to coordinate inspections of LLRW shipments.

In connection with the potential shipment of spent nuclear fuel and high-level radioactive waste from the decommissioning of Yankee Rowe (and, later, Pilgrim Station),[25] Massachusetts should establish a cooperative arrangement with Connecticut and any other state whose transport requirements require shipments to stop at night. This rule forces LLRW shippers to stop on the Massachusetts border overnight, or instead to drive longer, out-of-the way routes in order to proceed on their journeys.

Shipments of LLRW and radioactive materials will continue to occur in Massachusetts as long as the approximately 450 licensed users produce products and services for the Commonwealth and the nation.

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[25] Chapter 14 discusses decommissioning issues for the nuclear-powered electric generating plants as well as other radioactive materials users.

All actions of the Commonwealth are designed to be compatible with federal transportation requirements, and to prevent LLRW from causing any public health or environmental problems. With state oversight, the present excellent accident and incident record of these shipments will continue.

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Appendix 9A: Summary of Transportation Accidents, 1971-1993

The 49 transportation accidents summarized here involved shipments of LLRW in which **no release** of radioactivity occurred. A transportation "accident" involves the vehicle transporting the waste, and can range from a minor accident to a major collision. It does not involve the release or suspected release of LLRW. Transportation "incidents," on the other hand, involve the release of radioactivity, and are not included in this appendix. Only five "incidents" occurred between 1971 and 1993;[1] they are summarized in Section 9.6 of Chapter 9.

Data was supplied by the Radioactive Material Incident Report system at Sandia National Laboratories, Albuquerque, New Mexico.

No release of material or radioactivity was associated with the 49 low-level radioactive waste (LLRW) transportation accidents reported since 1971. Brief descriptions follow.

1. <u>03/09/73</u>: A tractor-trailer transporting a cask of spent resins from Vermont Yankee Nuclear Power Plant to Barnwell, South Carolina, was traveling on U.S. 301 south of Orangeburg, South Carolina, when the brakes failed. To avoid oncoming traffic, the driver maneuvered the truck across the median and hit a passenger car. The cask fell off the trailer; no radioactivity was released.

2. <u>06/14/74</u>: A train transporting LLRW from Ohio to Hanford, Washington, derailed near Deer Lodge, Montana. Two hundred eleven steel drums containing 28.55 grams of plutonium-238 were not damaged; no release of radioactivity occurred.

3. <u>08/07/74</u>: A tractor-trailer transporting LLRW from New Hampshire to the former Maxey Flats facility in Kentucky tipped while rounding an inclined curve on I-77 in Ohio. A cask rolled off the trailer and landed in a ditch. It was not damaged; no radioactivity was released.

4. <u>08/14/74</u>: A truck transporting LLRW from Oyster Creek Nuclear Power Plant, New Jersey, to the former Maxey Flats facility in Kentucky entered Nuclear Energy Company grounds in Kentucky on a narrow one-lane road. The trailer tandems went off the road onto the muddy shoulder. The truck overturned, but a cask stayed on the trailer and remained intact. It was undamaged; no radioactivity was released.

5. <u>01/06/75</u>: A tractor-trailer transporting LLRW from Wilmington, North Carolina, to Barnwell, South Carolina, was traveling near the intersection of I-95 and SC 378 in South Carolina when

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[1] According to the manager of the Sandia accident/incident reporting system, delays can occur between the time an accident or incident occurs, and the submission of an accident report from the U.S. Department of Transportation to the Sandia program. Therefore, accidents that occurred in late 1993 which were initially described as "non-events" could, conceivably, be reviewed and elevated to "accident" status.

it was broadsided by a two-ton truck. Fifteen wooden boxes containing uranium-235 waste were not damaged; no radioactivity was released.

6. 01/22/75: A van pulling a trailer transporting LLRW from Maryland to Barnwell, South Carolina, jackknifed, hit another vehicle, and then hit the guardrail in Washington, D.C. Of the eight 5-gallon pails, eighty-two 55-gallon drums, and seven 8-cubic-foot boxes in the shipment, eight were damaged, but no radioactivity was released.

7. 10/23/75: A flatbed trailer truck transporting LLRW from Oyster Creek Nuclear Power Plant, New Jersey, to the former Maxey Flats facility, Kentucky, ran off the road and overturned near Morgantown, West Virginia. A Type A cask containing LLRW was thrown off the trailer, but was not damaged. No radioactivity was released.

8. 03/15/76: A tractor-trailer transporting spent resins from Vermont Yankee Nuclear Power Plant to the former Maxey Flats facility in Kentucky, was involved in a minor accident on I-84 in New York. The shipment of spent resins in a Type A package was undamaged; no radioactivity was released.

9. 04/05/76: A trailer transporting a 30-thousand-pound cask to Kentucky from Northeast Utilities Millstone Power Plant in Connecticut struck an overpass on Hwy 66, south of Middleton, Connecticut. The cask was not damaged; no radioactivity was released.

10. 08/06/76: A truck with an open top trailer transporting demineralizers from the Charleston Naval Shipyard in South Carolina to Barnwell, South Carolina, was traveling near Snelling, South Carolina, when the driver applied the brakes on an approach to a stop sign, and felt the load shift. Braking again, to make a left turn, the truck turned on its side and two casks went through the cloth top of the trailer, and one went through the trailer. They were undamaged, and no radioactivity was released.

11. 09/08/77: The driver of a tractor-trailer transporting LLRW from Oyster Creek Nuclear Power Plant, New Jersey to Barnwell, South Carolina, swerved to miss a turning car and ran up an embankment into a field in South Carolina. A cask containing solidified evaporator bottoms was undamaged; no radioactivity was released.

12. 11/09/77: A tractor-trailer carrying LLRW from Vermont Yankee Nuclear Power Plant to Barnwell, South Carolina, was traveling on I-95, north of Rocky Mount, North Carolina, when the driver rear-ended another truck. One cask remained intact; no radioactivity was released.

13. 04/05/78: A truck transporting LLRW from the Robert E. Ginna Nuclear Plant in New York, to Barnwell, South Carolina, was traveling near Winchester, Virginia, when it had a tire blowout. The LLRW shipment shifted, but remained secured. No radioactivity was released.

14. 07/07/78: A tractor-trailer transporting LLRW from the Millstone Nuclear Power Plant in Connecticut to Barnwell, South Carolina, was traveling on US 301, south of Orangeburg, South Carolina, when the driver swerved the truck to avoid a collision, and hit a utility pole. A Type B cask containing mixed fission products was undamaged, no radioactivity was released.

15. 08/29/78: A truck transporting LLRW from Illinois to Barnwell, South Carolina struck a guardrail and overturned on I-24 near the Tennessee-Georgia border. A cask holding eighteen 55-gallon steel drums of solidified reactor coolant was not damaged; no radioactivity was

released.

16. 09/13/78: A tractor-trailer transporting a contaminated lifting yolk from Nebraska to Barnwell, South Carolina, was traveling on I-70, west of St. Louis, Missouri, when the yolk broke through the trailer floor. The yolk was raised, shored, and fastened without incident; no radioactivity was released.

17. 12/19/78: A truck transporting LLRW from Minnesota to the former Sheffield facility in Illinois was traveling on I-90/94 north of Madison, Wisconsin, when the driver swerved to avoid a car collision. The rig overturned in the median. Thirty-nine 55-gallon drums containing depleted uranium-238 waste were undamaged; no radioactivity was released.

18. 01/28/79: A tractor-trailer transporting LLRW from Dresden, Illinois, to Barnwell, South Carolina, was traveling on I-24 east, near Monteagle, Tennessee, when the driver lost control on a icy grade, and the truck overturned. Forty-six 55-gallon drums containing contaminated clothes and rags fell out onto the highway. Four drums were damaged, but there was no release of radioactivity.

19. 03/20/79: A tractor-trailer transporting LLRW from Nebraska to Barnwell, South Carolina, was stopped on the shoulder of I-70, 60 miles west of St. Louis, Missouri, when it was struck from behind by a meat truck. Two steel drums and one wooden box were damaged out of the shipment of 57 steel drums. No radioactivity was released.

20. 06/18/79: A tractor-trailer transporting LLRW from Commonwealth Edison Company in Illinois to Barnwell, South Carolina, was traveling on I-26, northwest of Columbia, South Carolina, when it was involved in an accident. A Type A cask containing 14 drums of spent resins was undamaged; no radioactivity was released.

21. 08/03/79: A pickup truck was involved in an accident while transporting LLRW from a laundry near Barnwell, South Carolina, to the disposal facility in Barnwell. No radioactivity was released.

22. 12/09/79: A tractor-trailer transporting LLRW to Hanford, Washington, was traveling on an icy I-90, west of Missoula, Montana, when, in the fog, it hit an abandoned car parked on the shoulder. A wooden box containing one curie of noncompacted LLRW was not damaged; no radioactivity was released.

23. 12/12/79: A tractor-trailer transporting LLRW from the University of Wisconsin to Hanford, Washington, was struck by a car driven by a drunk driver on I-90, east of St. Regis, Montana. The shipment was undisturbed; no radioactivity was released.

24. 01/11/80: A truck transporting LLRW on Rt. 9 in Montrose, New York, was involved in an accident. The shipment of two 5-gallon pails and seven 55-gallon steel drums was intact; no radioactivity was released.

25. 01/31/80: A tractor-trailer transporting uranium and mixed fission products from New York to Barnwell, South Carolina, was traveling on I-95 near Roanoke Rapids, North Carolina, when it jackknifed and came to rest on the median. The shipment included one cask containing 230 grams of uranium and 700 curies of mixed fission products, and another cask containing 238 grams of uranium and 933 curies of mixed fission products. Both casks were Type B packages. Two other vehicles were involved, but there were no injuries. The casks were undamaged and no radioactivity was released.

26. 02/15/80: A tractor-trailer transporting krypton-85 from Arizona to Barnwell, South Carolina, collided with a car that pulled out in front of it in Phoenix, Arizona. A 20-pound fiberboard box containing a source tube shifted position. The radiation level outside the box increased to 30 Mr/hr at the surface. Although there was no release of materials, the box was returned to the shipper for repackaging.

27. 02/22/80: A tractor-trailer transporting LLRW from Ohio to Beatty, Nevada, was traveling on I-70, west of Columbus, Ohio, when it was struck by a pickup truck. The LLRW was packed in strong, tight packages; no radioactivity was released.

28. 04/18/80: A tractor-trailer transporting LLRW from Metropolitan Edison Company in Pennsylvania to Barnwell, South Carolina, was traveling on Grant Street in Middleton, Pennsylvania, when the rig decoupled at an intersection. The trailer dropped down on a parking dolly. The rig was recoupled and driven to a truck stop for inspection. The cargo was not damaged; no radioactivity was released.

29. 06/22/80: A tractor-trailer transporting LLRW from the Monticello Nuclear Power Plant in Minnesota to Hanford, Washington, was traveling near Glendive, Montana, when a sudden, strong gust of wind caused the truck to jackknife and slide into a ditch. Eight wooden boxes and sixteen 55-gallon steel drums were undamaged; no radioactivity was released.

30. 12/22/80: A tractor-trailer transporting LLRW from the Northeast Nuclear Energy Company in Connecticut to Barnwell, South Carolina, was traveling near Bordentown, New Jersey, when it was involved in an accident. A Type A cask containing 570 millicuries of mixed fission products was undamaged; no radioactivity was released.

31. 06/16/81: A tractor-trailer transporting dewatered resins from the Salem Nuclear Power Plant in New Jersey to Barnwell, South Carolina, was traveling on I-95, south of Dillon, South Carolina, when it rear-ended another tractor-trailer. The tractor was damaged, but the cargo remained intact. The shipment included a Type A cask containing 200 cubic feet of dewatered resins and 3 curies of activated corrosion products; no radioactivity was released.

32. 08/12/81: A tractor-trailer transporting LLRW from the Turkey Point Nuclear Power Plant in Florida to Barnwell, South Carolina, was passing a farm tractor on Rt. 3, north of US 601 in South Carolina, when a collision occurred. The shipment of 0.592 curies of general trash (cloth, plastic, wood, gloves, etc.) was not damaged, and no radioactivity was released.

33. 11/23/81: A tractor with two trailers transporting LLRW from Colorado to Beatty, Nevada was traveling on US 6 near Denver, Colorado, when it slid off the highway into a snowbank. Twenty-eight fiberboard boxes (14 in each trailer) containing nitrate salts with americium and uranium oxidizers and 0.00171 curies of plutonium were not damaged; no radioactivity was released.

34. 01/07/82: A tractor-trailer transporting LLRW from Cincinnati, Ohio, to Hanford, Washington, was traveling on I-86, east of Burley, Idaho, when the truck slid off the icy road into the snow. The cargo was not damaged; no radioactivity was released.

35. 05/06/82: A tractor-trailer transporting LLRW from Ohio to California was traveling through Salt Lake City, Utah, when an oil line ruptured, spraying oil onto the engine, and causing a fire to the tractor portion of the vehicle. The package of depleted uranium was undamaged; no radioactivity was released.

36. 11/03/82: A tractor-trailer transporting two empty Type B casks from Barnwell, South Carolina, to New York was traveling near Hilda, South Carolina, when a car pulled out in front of the truck, causing the truck to overturn. Both cask tie-downs gave way and the casks were thrown from the trailer. The tractor caught fire. Both casks were intact and undamaged. No radioactivity was released.

37. 12/14/82: A tractor-trailer transporting LLRW from the University of Minnesota to Hanford, Washington, ran off an exit ramp off I-94 near Beach, North Dakota, due to icy road conditions. The shipment, including 55-gallon steel drums containing hydrogen-3, iodine-125, iron-55, and carbon-14 was undamaged; no radioactivity was released.

38. 03/11/83: A tractor-trailer transporting a Type B cask containing LLRW from Wisconsin to Hanford, Washington, was traveling on IL 59 in Illinois when it was side-swiped by another truck. The cask was not damaged and no radioactivity was released.

39. 06/22/83: A tractor-trailer transporting LLRW from New York, New York, to Hanford, Washington, was travelling on I-95 South trying to take the exit to the George Washington Bridge, when a car struck the back of the trailer. The shipment included one hundred and seventy-seven 55-gallon drums of LLRW containing iodine-125, carbon-14, and phosphorus-32 from New England hospitals. Five nonradiologically-related injuries resulted from the collision, but the shipment was undamaged. No radioactivity was released.

40. 10/11/83: A flatbed trailer truck transporting LLRW from Consolidation Coal in Jollytown, Pennsylvania, to Hanford, Washington, was traveling on U.S. 250 near Cameron, West Virginia, when the driver went left of center and struck an oncoming car. Five Type A steel canisters were undamaged; no radioactivity was released.

41. 12/18/83: A tractor-trailer transporting LLRW from Philadelphia, Pennsylvania, to Hanford, Washington, was traveling on an icy I-84 near King Hill, Idaho, when the driver tried to avoid hitting a car, and slid into a rock wall. One container in the shipment needed an overpack to continue to Hanford; the other containers were undamaged. No radioactivity was released.

42. 05/04/84: A tractor-trailer transporting LLRW from Ohio to Beatty, Nevada, was travelling on I-70 near Greenville, Illinois, when a fire erupted from the right rear drive axle. Two of the 19 wooden boxes were damaged, but no radioactivity was released.

43. 05/28/84: A tractor-trailer transporting LLRW from New Jersey to Hanford, Washington, was traveling on I-80, east of Rock Springs, Wyoming, when the truck overturned. Fifteen fiberboard boxes containing carbon-14, technetium-99, and iodine-129, were unloaded and transferred to another trailer. The boxes were undamaged and no radioactivity was released.

44. 04/02/85: A tractor-trailer transporting LLRW was travelling on I-390 in New York when it slid into a guard rail on an icy bridge. The driver braked to avoid an accident ahead, and the trailer jackknifed. The shipment included pumps and equipment, which remained intact and undamaged. No radioactivity was released.

45. 04/11/85: A tractor-trailer transporting LLRW from the Peach Bottom Nuclear Power Plant in Pennsylvania to Hanford, Washington, was traveling on US 11/15 in Enola, Pennsylvania, when it was involved in a traffic accident. The tractor trailer sustained minor damage, but the 14 metal boxes of LLRW were not damaged; no radioactivity was released.

46. 01/16/86: A tractor-trailer transporting LLRW from a company in Washington to Hanford, Washington, was traveling on Hwy 243, near Mattawa, Washington, when the truck skidded on black ice and the trailer jackknifed but did not overturn. The shipment included thirty 55-gallon steel drums containing carbon-14, iodine-125, iodine-131, chromium-51, and phosphorus-32. The drums remained intact and undamaged; no radioactivity was released.

47. 03/15/86: A tractor-trailer transporting LLRW was traveling in Brooklyn, New York, when it became wedged under elevated railroad tracks. The driver was cited for not following the designated DOT route for hazardous materials and for reckless endangerment. The shipment of two hundred forty-six 55-gallon steel drums was not damaged, but was transferred to another vehicle. No radioactivity was released.

48. 03/28/87: A tractor-trailer transporting solidified filters from LaSalle, Illinois, to Beatty, Nevada, had stopped for the night during a snow storm in Des Moines, Iowa. During the night, the driver was awakened to move the rig, and the rear axle slid into a ditch. A 70-thousand-pound Type A cask was undamaged; no radioactivity was released.

49. 05/19/89: A tractor-trailer transporting LLRW from Harrisburg, Pennsylvania, to Hanford, Washington, was traveling on Rt. 90, east of Bozeman, Montana, when hit by a passenger car. The truck managed to stop and make repairs without further incident. The shipment of a Type B cask containing Class C LLRW was undamaged, and no radioactivity was released.

Appendix 9B: A Case Study of One LLRW Shipment

A report on the transportation of low-level radioactive waste (LLRW), which was issued in December, 1986, by the Special Legislative Commission on Low-Level Radioactive Waste, contained a section describing the packaging and transport of one LLRW shipment from the company which produced the waste to an out-of-state disposal site.[1]

This "case study" approach is repeated here, using a 1990 shipment from the same LLRW generator described by the Special Commission (E.I. Du Pont De Nemours and Company) instead of the 1985 shipment tracked in the Special Commission's document.

This example of activities involved in a waste shipment illustrates not only the types of routine safeguards that all shippers must take for waste transportation, but also shows the practices that an LLRW generator can develop to improve its management of its particular waste stream.

Du Pont is one of the largest users of radioactive materials and producers of LLRW in M-assachusetts. Located in Billerica and Boston, the company's products are shipped throughout the state and world-wide to hospitals and other medical facilities for use in detecting cancer and other diseases.

In response to escalating costs of LLRW transportation and disposal, Du Pont has adopted an aggressive waste minimization policy, and strives to reduce the generation of all types of waste (radioactive, hazardous, and solid) by 10% each year. The company utilizes employee education and training, radioactive materials substitution, and innovative packaging techniques to reduce the radioactive source materials utilized in its manufacturing activities, as well as the volume of LLRW produced as a by-product of those activities. Du Pont's efforts are also focused on increasing the isolation of the waste during transport and disposal. In addition, Du Pont has developed a comprehensive computerized system to inventory and track its waste.

Like all other LLRW generators who ship LLRW to processing and disposal sites, Du Pont must meet DOT and NRC requirements for package integrity, radiation level limits, and transport vehicle safety throughout the packaging, loading, and shipping process. However, Du Pont differs from many other waste producers in that it developed[2] a unique packaging system specifically for the large quantity of tritium in its LLRW stream. Tritium, a radionuclide formed from hydrogen, is used in the manufacture of medical test

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[1] The Special Commission on Low-Level Radioactive Waste was established to evaluate regional solutions for Massachusetts LLRW disposal and to recommend legislation to manage all LLRW produced in the Commonwealth. Some of the Special Commission's transportation report has been generously adopted for use in portions of this chapter.

[2] Du Pont began research and development on its special package in 1983. In November, 1985, the company received license approval from the NRC and authorization from the State of Washington and the Hanford, Washington, disposal site, which was to accept the special package.

kits, and has a half-life of 12.3 years.

The focus of this case study is a shipment containing only tritium waste packaged in a High Integrity Container, nicknamed a "HIC," which contains Du Pont's specially developed tritium inner package, called a Special Stabilized Package (SSP).

Large Volumes of Tritium Wastes

Roughly 25% of the research products manufactured by Du Pont Medical Products are produced from tritium compounds, resulting in a large amount of tritium-contaminated waste each year. Since so much of Du Pont's waste stream contains this single radionuclide, the company developed a process for recycling between 40 and 50% of its higher concentration tritium waste for reuse in its production process, rather than sending this waste for disposal.

Like most LLRW, tritium is usually packaged in 55-gallon steel drums. An absorbent, such as "speedi-dry" (a commercial diatomaceous earth product used to clean up oil leaks) is added to the tritium-contaminated liquid waste to stabilize it for transportation and disposal. Under DOT regulations, each 55-gallon drum may contain up to eight curies of tritium waste.

For some of its tritium waste, however, Du Pont developed a special ten-gallon container, the Special Stabilized Package (SSP), which packages the waste more effectively and safely so that up to 10,000 curies of tritium -- instead of eight curies, can be packaged into a single 83-gallon HIC and shipped for disposal. Each HIC holds up to three SSP containers. This system takes up considerably less volume at the disposal sites: one 83-gallon HIC containing three SSP's holds as much tritium waste as 2,700 of the 55-gallon drums packed in the conventional method. Greater isolation of the tritium waste is achieved as well, thereby reducing the threat of potential public health and environmental contamination.

Waste Management in the Lab

The first step in managing the waste contained in the Nov. 13, 1990, shipment began in the lab. The tritium gas used in Du Pont's manufacturing process in Boston is trapped during production in specially-designed thick-walled glass flasks. Glass is used because it is a better shield than normal carbon steel (which tritium can penetrate over time when pressure builds up from the radiolysis of any organic chemical in the waste), and has passed pressure tests of 600 pounds per square inch. The glass flask is the first layer of radiation protection provided to the waste, and is placed into other containers comprising the SSP. The glass flask was not considered in NRC's analysis and approval of the SSP package design integrity, and therefore provides an extra barrier beyond the requirements of NRC.

Tracking an LLRW Shipment: In the Lab

1. Open source tritiated gas cylinder in lab for use in production of research product.
2. Trap tritium contaminated waste gas in glass flask filled with absorbent.
3. Seal glass flask.
4. Transfer flask to waste processing area in tins of absorbent.

The glass flasks used to trap the tritium waste contain absorbent and have narrow necks so that the opening can be sealed off in the lab. The sealed flasks are tested for integrity, and transferred in tins of absorbent from the lab to the waste processing area of Du Pont's Boston facility.

Tracking an LLRW Shipment: Waste Processing Area, Boston

5. Set flasks in aluminum tubes of absorbent.
6. Cap, seal, weld, and ultrasonically check aluminum tubes.
7. Label with quantity and contents of waste.
8. Insert three aluminum tubes in 1/4 inch thick stainless steel cylinder.
9. Weld stainless steel cap onto cylinder.
10. Check weld integrity by ultrasound.
11. Label with quantity and contents of waste.
12. Fill out shipping papers for trip to Billerica.
13. Check SSP surface contamination levels.
14. Transport SSPs to Billerica.

In Waste Processing Area, Boston

In the waste processing area, aluminum is used as the next barrier in the package, because tritium gas will not pass through this metal. Up to three of the glass flasks, depending on the total curies per flask, are placed into an aluminum tube. The tubes are capped, sealed and welded shut, and checked by ultrasound for any welding deficiencies. Then they are labeled with the quantity and type of radionuclides.

Three of the aluminum tubes are placed in a 1/4 inch thick stainless steel cylinder. This combination of the aluminum tube inside the stainless steel cylinder comprises the "Special Stabilized Package," or "SSP."

A cap is welded onto the cylinder too, and the integrity of each weld is tested.

The NRC requires that welds be perfect for shipping and disposal. Ultrasound checks reveal, on average, that only one out of 300 stainless steel cylinders requires rewelding before continuing through the rest of the waste management process.

Each SSP cylinder is labeled to identify the contents. In bi-monthly shipments, cylinders are transported to Du Pont Merck's plant in Billerica, where they are stored in a waste processing building. Prior to shipping to Billerica, each container of waste is checked for surface contamination levels, accurate and complete labeling, and to ensure that the information on the shipping papers corresponds with the markings on the containers as they are loaded onto a truck.

Once loaded, surface radiation readings are taken on six sides of the transport vehicle to ascertain that limits set by the DOT are not exceeded. The driver carries two sets of shipping papers identifying the contents of the shipment. One duplicate set is stapled inside the trailer.

If Boston does not receive word that a shipment has reached Billerica within 1/2 hours of leaving Boston, Boston investigates immediately. To date, Du Pont has experienced no problems with overdue shipments. Once the waste shipment reaches Billerica, it is unloaded and taken into the waste storage building.

In Waste Management Building, Billerica

When three cylinders of tritium waste have accumulated in temporary storage in Billerica, they can be packed into an 83-gallon cement-lined steel drum, the High Integrity Container, or "HIC." "Speedi-dry" absorbent is added around the three cylinders, to fill up approximately one-half of the container and act as a cushion for the cylinders. The HIC is then sealed with a steel cover lined with cement, so that the cement lining of the drum tightly meets the cement of the cover. Before the cover is put in place, an epoxy-resin material is spread around the top of the drum; the epoxy substance "glues" the cover tightly and

permanently in place.[3]

> **Tracking an LLRW Shipment: Waste Management in Billerica**
>
> 15. Unload SSPs for temporary storage.
> 16. Pack three SSPs in High Integrity Container (HIC).
> 17. Add absorbent to steel cylinders.
> 18. Seal HIC cover with epoxy-resin.
> 19. Label and mark drums for shipment.
> 20. Complete inspection #1 on quality assurance checklist.

Figure 9B-A shows a cross-section of the HIC and its contents.

Each Du Pont HIC has six separate labels and markings to identify its contents. On one side of the HIC is a "Radioactive White I" symbol and a "7A Type A" marking indicating DOT categorization of the package type for transport purposes. On the opposite side of the cylinder is another "Radioactive White I" symbol and the shipper's label containing a 24-hour emergency number to call. On the top of the HIC is a "Class B stable" marking indicating the NRC classification of the waste for disposal site purposes.

The sixth label is called a "Radwaste Container QA (quality assurance) Checklist." This label incorporates all of the information marked on the HIC as well as radiation readings from the surface of the HIC and the destination of the shipment. This checklist covers two inspections performed by two separate employees. The first inspection occurs when the HIC is sealed; the second occurs when the drum is shipped.

One side of the QA Checklist form showing the information entered after one HIC has been sealed appears in Figure 9B-B.

The QA Checklist also contains information from Du Pont's shipping code system. This computerized system includes a four-digit shipment code indicating the shipment number for the year, and a 16-digit identification code. The 16-digit code is keyed to computer data on the volume, curies, and type of radionuclide in each container, as well as which lab generated the waste through what activities on which day, and who was responsible at each stage of the waste handling process.

This system of labeling is used for all Du Pont LLRW shipments, not just for its HIC shipments containing the Special Stabilized Packages, and gives Du Pont access to vital information in the event of any radioactive release or emergency during shipment and even after disposal.

Packing HICs into Overpack

The tritium-contaminated waste in the SSP/HIC package is shipped to the Hanford, Washington, disposal site in a rectangular box made of steel and concrete. This container, called an "overpack," is approximately 10 feet long by six feet wide and four feet high. It is **not** used for waste disposal, only waste shipment, in this case. The overpack is bolted onto a flat-bed trailer, leased by Du Pont from US Ecology (operator of the Hanford, Washington site) for each shipment. Du Pont uses this system only three times a year, transporting three HICs in each shipment.

Before the HICs can be loaded into the overpack, the box is checked for radioactive contamination and radiation. The vehicle is also checked to see if it meets DOT specifications for "roadworthiness." This

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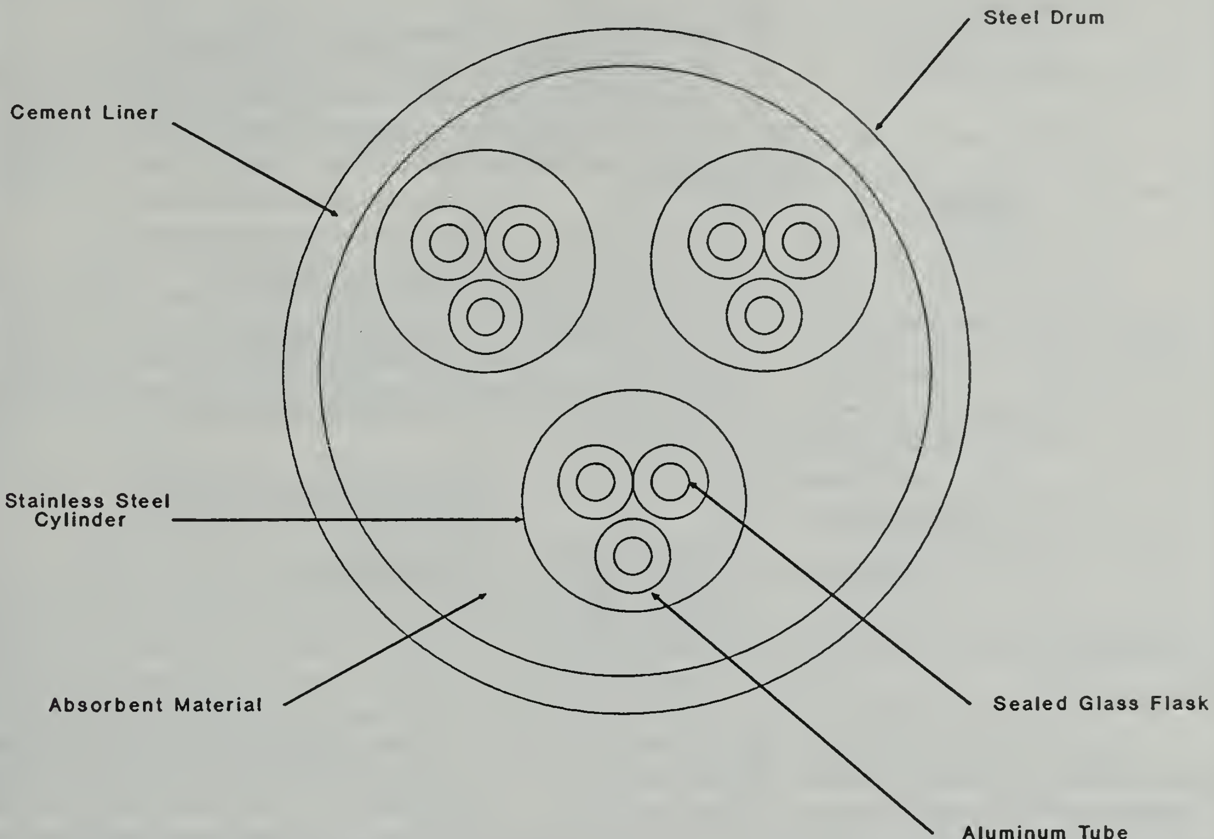
[3] Du Pont originally received approval to use the SSP cylindrical container as the final disposal container. These containers were labeled with "Radioactive White I" symbols on the sides, and a "Class B stable" marking on the tops, as well as Du Pont's own shipping codes. They were then transported to Hanford, Washington, for disposal. The NRC, Washington State, and the Hanford disposal site later approved of the further isolation of three SSP's in a cement-lined steel drum.

Figure 9B-A
Cross-Section of HIC and Contents



Source: E.I. Du Pont De Nemours and Company, Billerica, MA, 1991.

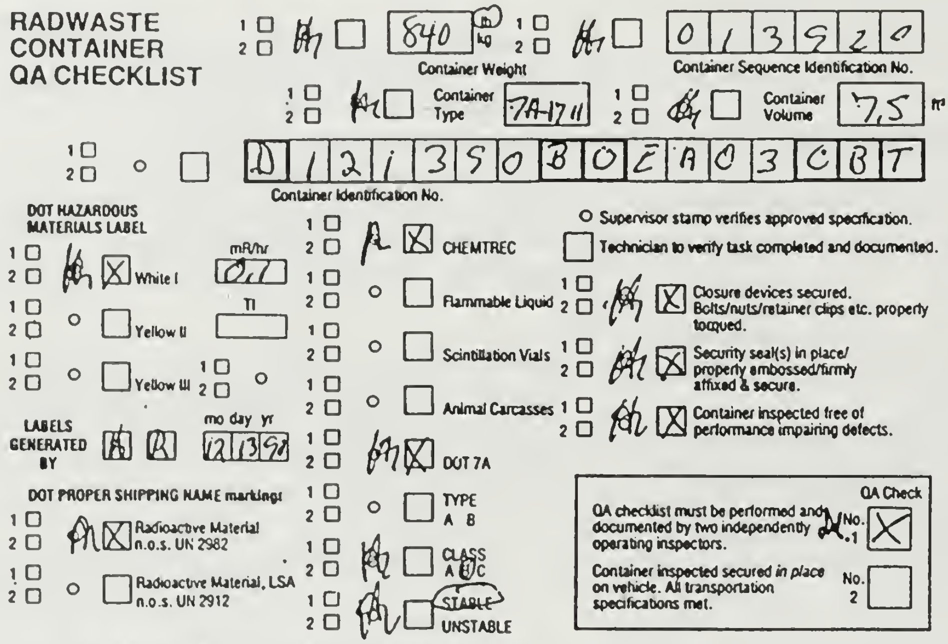
check includes tires, headlights, signals, brakes, mirrors, and frame. Prior to loading the shipment, the HIC's are cleaned and wipe-tested to measure for any surface contamination. The second side of the QA Checklist form is completed and certified accurate by an Inspector.

During the loading process, several employees check each labeled drum against the manifest of waste to be shipped. After the loading, a repeat check occurs to ensure that the containers in the overpack match the information on the shipping papers. Du Pont uses a seven-page checklist for every waste shipment.

Three HICs containing up to 30,000 curies of tritium are lifted by crane into the overpack. They are laid on their sides, and braced on all sides with wooden two-by-fours. Then the overpack cover is slowly lowered onto the box, and sealed for shipment. The overpack is labeled with "Radioactive White I" signs and with the shipper's 24-hour emergency telephone number.

Two sets of shipping papers are sent with the shipment and one is stapled inside the trailer. The shipping papers are carried in an envelope upon which a nontechnical, general description and breakdown of the load are printed so that if the vehicle is stopped for inspection en route, state police will have a better nontechnical understanding of the contents of the shipment.

Figure 9B-B
One of Six Labels Used to Mark Du Pont's HIC


RADWASTE CONTAINER QA CHECKLIST

840 m kg — Container Weight

0 1 3 9 2 0 — Container Sequence Identification No.

Container Type 7A-1711

Container Volume 7.5 ft³

D 1 2 1 3 9 0 B 0 E A 0 3 C B T — Container Identification No.

DOT HAZARDOUS MATERIALS LABEL

White I — mR/hr 0.7

Yellow II — TI

Yellow III

LABELS GENERATED BY — mo day yr 12 13 91

DOT PROPER SHIPPING NAME markings

Radioactive Material n.o.s. UN 2982

Radioactive Material, LSA n.o.s. UN 2912

CHEMTREC

Flammable Liquid

Scintillation Vials

Animal Carcasses

DOT 7A

TYPE A B

CLASS A B C

STABLE UNSTABLE

○ Supervisor stamp verifies approved specification.

☐ Technician to verify task completed and documented.

Closure devices secured. Bolts/nuts/retainer clips etc. properly torqued.

Security seal(s) in place/ properly embossed/firmly affixed & secure.

Container inspected free of performance impairing defects.

QA Check

QA checklist must be performed and documented by two independently operating inspectors. — No. 1

Container inspected secured *in place* on vehicle. All transportation specifications met. — No. 2

Source: E.I. Du Pont De Nemours and Company, Billerica, MA, 1991.

Even though the driver is an experienced instructor for drivers of LLRW shipments, he is given instructions about the load as required by DOT regulations. Du Pont must verify that the driver understands the waste is being transported in an "exclusive use vehicle," meaning that any changes in the contents of the trailer are under the control of the shipper during transport. The driver must also certify that he or she has been told who to notify in the event of a problem or emergency and what action to take while waiting for emergency personnel to arrive.

Before the overpack shipment leaves Billerica, pictures are taken of the driver and the trailer, as a separate record of the shipment.

En Route to Washington

The truck leaves Billerica and travels north on Route 3 to I-495, then south on Route 495 to the Massachusetts Turnpike. From there it travels through New York to the mid-west, and then out west to Washington State. Depending upon the weather, the total trip takes four to five days.

The cities of Spokane and Plymouth are the only two points of entry for radioactive waste shipments into Washington. Shipments are inspected at these checkpoints by the state police before proceeding to Hanford.

Upon arrival at the disposal site, the waste is inspected by state authorities and the site operator, US Ecology. Inspectors check to make sure that waste is properly packaged and labeled and that the shipment is accompanied by an accurate shipping manifest and generator certification regarding the adherence to all regulations. If any violations are found, the site may suspend the generator's access to the site. Any packaging deficiencies must be corrected before waste can be accepted for disposal.

Once unloaded, the trailer and overpack are surveyed for contamination and radiation, and decontaminated if necessary. The site must notify the generator within a week of the shipment's arrival.

Du Pont's costs to ship and dispose of three HICs containing up to 30,000 curies of tritium, including renting the overpack and the loading crane, are $32,000. Adding labor costs to manage the tritium waste between the lab and the shipping vehicle, the total cost of this tritium-contaminated LLRW shipment is $35,000.

Were Du Pont to utilize 55-gallon drums, which can hold only eight curies of tritium under DOT standards, it would have cost the company approximately $1.9 million dollars ($1,700 x 2,700 drums, in 1991 dollars) to dispose of the same quantity of tritium waste, and the extra disposal packages would have unnecessarily consumed valuable waste disposal space.

Tracking an LLRW Shipment: Packing HICs into Overpack

21. Check overpack for radioactive contamination.
22. Check vehicle for "roadworthiness."
23. Clean and wipe-test HICs.
24. Complete inspection #2 on quality assurance checklist.
25. Load three HICs into overpack.
26. Check and re-check labels against shipping manifest during loading.
27. Survey and record detectible radiation levels on surfaces of loaded trailer.
28. Staple copy of shipping papers inside cab. Driver carries two sets of shipping papers.
29. Brief driver on route and emergency response for LLRW transportation.
30. Complete seven page Du Pont quality assurance checklist.
31. Du Pont or agent prenotifies Washington disposal facility of shipment.
32. Photograph driver in front of sealed, placarded truck as record of shipment condition at point of origin.

Other Shipments in 1990

The three HICs in the Nov. 13, 1990 shipment were among approximately 550 packages transported for disposal by Du Pont during 1990. Du Pont uses seven basic types of NRC-approved containers for waste shipments, and ships other radioactive waste besides tritium. The company also transports compactable waste to a Tennessee firm for "supercompaction" before it is shipped to a disposal site.[4]

Tracking an LLRW Shipment: On the Road to Washington

33. Truck travels west via Massachusetts Tumpike. Shipment is weighed.
34. Shipment is inspected upon arrival at Plymouth, Washington.
35. Site operator inspects shipment upon arrival at Hanford disposal site.
36. HICs are unloaded for disposal.
37. Hanford site operator notifies Du Pont within one week of shipment's receipt.

The packaging types include 55-gallon Type 7A steel drums, 83-gallon drums, large (between 90 and 98 cubic feet) steel boxes, and 30-gallon Type 7A steel drums. Du Pont does not use previously-used drums for disposal, but does use re-cycled drums to ship waste to Tennessee for further processing. Federal regulations, and those of the disposal sites, allow the use of reconditioned drums for disposal.

The Nov. 13, 1990, shipment of three HICs contained 22,000 curies of tritium waste. The total volume of Du Pont's waste shipped in 1990 was 8,645 cubic feet; the total curies shipped were 56,623.5.

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[4] Readers today should know that Du Pont tritium shipments are now being sent to the disposal site in Barnwell, South Carolina. The Hanford, Washington, disposal site closed to all states outside the Northwest and Rocky Mountain regions on Dec. 31, 1992. See Chapter 15 for additional information on the accessibility of disposal sites.

Chapter 10: LLRW Treatment Practices

10.1 Introduction

Minimizing the amount of radioactivity in low-level radioactive waste (LLRW) **prior** to its generation by various methods is called "source minimization." Reducing the volume of LLRW **after** its generation through various treatment techniques is called "volume minimization." Both concepts are among the chief goals of Massachusetts LLRW management law.

The Massachusetts Low-Level Radioactive Waste Management Board views the **principal** objective of any minimization program to be source minimization, and source elimination, where practical.

These policies are not unique to LLRW management. Massachusetts has been a national leader in establishing policies and laws aimed at preventing various types of wastes from being produced, and reducing wastes that will eventually require disposal. State laws supervising and regulating toxic chemical waste -- called "hazardous" waste, and laws controlling household and industry trash -- known as "solid" waste, also require reductions of toxicity at the source, and minimizations of waste volumes after the wastes are produced. The Massachusetts Toxic Use Reduction Act, Massachusetts General Laws c.21I, which sets out a plan for the Commonwealth to reduce the use of toxic materials by 50% by 1997, is a landmark source reduction law, which has since been copied by other states.

The Low-Level Radioactive Waste Management Act, Massachusetts General Laws c.111H (Chapter 111H), directs the Commonwealth's efforts to manage and control LLRW. A key provision requires LLRW generators to prepare and implement source and volume minimization plans.

The successful achievement of source and waste volume minimization (S/WVM) or source and waste volume elimination (S/WVE) or both (S/WVM/E) was one of the major purposes of an LLRW management law identified in testimony during public hearings on the first drafts of Chapter 111H. Numerous citizens expressed concern that managing LLRW should not mean simply developing waste storage, treatment, or disposal capacity, even if such capacity could be found out of state. The public wanted assurances that disposal would be a "last resort." However, other speakers expressed concern that, while minimization objectives were a positive goal, setting specific percentage reduction goals could force some LLRW generators to abandon innovative medical research that can lead to advances in products and services involving the use of radioactive materials.

Chapter 111H, as adopted by the Legislature, addresses both concerns. It does not set percentage reduction goals, but contains a S/WVM mandate that is considered one of the strongest LLRW minimization principles in the country.

The law requires all LLRW generators to participate in a Massachusetts Department of Public Health (DPH) program "consistent with the protection of public health, safety, and the environment and with the promotion of responsible research and innovation." [Chapter 111H, section 13] It directs the DPH, after

consulting with the Management Board, to adopt regulations requiring generators "to prepare and implement plans for the utilization of all appropriate source minimization, volume minimization and storage for decay methods."

The enforcement of minimization plans and S/WVM methods is linked to the licensing of radioactive materials users pursuant to section 8 of Chapter 111H, which authorizes DPH to issue orders necessary to enforce the provisions of the statute. DPH orders may include modifying, suspending, or revoking licenses of anyone violating the law or the regulations adopted for its implementation.[1]

The Management Board's responsibility to provide DPH with recommendations for S/WVM regulatory development is articulated in section 12 of Chapter 111H, the section which identifies a group of policy issues for inclusion in this Management Plan. Section 12 directs the Management plan to include:

> "a review and analysis of the effectiveness and feasibility of, and the development of recommendations for, encouraging or requiring minimization of the volume, radioactivity, toxicity, or other characteristics of low-level radioactive waste." [Section 12(b)(9)]

This chapter contains such a review and analysis, as well as recommendations for a Massachusetts program of source and waste volume minimization and elimination (where feasible), and storage for decay. The specific elements of such a program are contained in Appendix 10A at the end of this chapter.

10.2 Source and Waste Volume Minimization and Elimination Policies

Policies involving S/WVM are scattered among several agencies on the federal and state levels, and their implementation, therefore, is somewhat inconsistent.

The U.S. Nuclear Regulatory Commission (NRC) established a policy on LLRW volume reduction in 1981, which is designed to encourage radioactive materials users to establish programs "commensurate with good volume reduction practices." Such actions, says the policy statement, will:

(1) extend the operational lifetime of the existing commercial LLRW disposal sites;[2]

(2) alleviate concern that adequate storage space will exist if there are delays in establishing new disposal facilities; and

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[1] DPH enforcement authority is available only if Massachusetts has an agreement with the U.S. Nuclear Regulatory Commission (NRC) to assume regulatory control of most licensed radioactive materials licensees (except research reactors, federal installations, and nuclear power plants). Massachusetts has applied for "Agreement State" authority. Without Agreement State authority, the State cannot enforce the source and waste volume minimization requirements of Chapter 111H.

[2] In 1981, the operating LLRW disposal sites included Beatty, Nevada; Barnwell, South Carolina; and Hanford, Washington. The Beatty site closed on Dec. 31, 1992. On that same date, the Hanford site closed to generators in all states but those in the Northwest and Rocky Mountain Compacts. Only the Barnwell site continues to be accessible to Massachusetts generators until June, 1994, but is expected to close permanently in 1995. In addition, as is noted in Appendix 1A of this volume, another LLRW disposal site is available to take certain limited types and concentrations of radionuclides in LLRW. That site is located in Utah, and is run by Envirocare of Utah, Inc. The limitations in the Envirocare license restrict that site's ability to take all the LLRW generated in Massachusetts and the nation.

(3) reduce the number of LLRW shipments.

The NRC urges radioactive materials licensees to follow a two-step volume reduction program. The first involves changes in administrative controls such as planning laboratory process activities prior to the actual operation; managing equipment to minimize leakage, spills, and waste volume; segregating radioactive and non-radioactive materials activities; and employee training. The second volume-reduction step is the installation of advanced volume reduction equipment, "if needed."

In addition to the NRC policy on volume reduction, a requirement for S/WVM exists in the law authorizing the U.S. Environmental Protection Agency (EPA) to regulate the hazardous components of "mixed" waste.[3] That requirement directs mixed waste generators to "have a program in place to reduce the volume and toxicity of waste generated to the extent that is economically practical."

The federal Low-Level Radioactive Waste Policy Act of 1980 (LLRWPA) directs the U.S. Department of Energy (DOE), as the lead federal LLRW management agency, to develop methods to reduce the amount of LLRW generated by its various research laboratories and by commercial users of radioactive materials. To implement this order, DOE is providing technical assistance on S/WVM policies and procedures to states who can, in turn, educate their LLRW generators.

A provision in the federal Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPAA) also helped achieve LLRW volume reductions. That law allows each of the three states that were operating disposal sites through 1992 for most LLRW generators in the country to limit the LLRW volumes they received. Specific annual limits appear in the law, and hold the maximum amount that may be accepted between 1986 and 1992 to a total of 19.6 million cubic feet, as shown on Table 10-1.

In addition, the LLRWPAA allows those sited states to limit the volume they accepted from nuclear-powered utility companies. Between 1986 through 1992, the total volume of reactor waste received at the three sites was 5,558,799 cubic feet, which represented only 28% of the reactor allocations allowed through 1992.[4] The rising cost of waste disposal has reduced the amount of LLRW nuclear plants have shipped for disposal.

Table 10-1
Disposal Capacity Limits at Three Commercial Disposal Sites
(In million cubic feet)

Site	Yearly Ceiling	1986-1992 Ceiling
Barnwell, S. Carolina	[illegible].2	8.4
Beatty, Nevada	0.2	[illegible].4
Hanford, Washington	1.4	[illegible]
Totals	2.8	19.6

Source: Low-Level Radioactive Waste Policy Amendments Act, Public Law 99-240, January, 1986.

[3] Mixed waste is LLRW that is contaminated with materials listed as hazardous chemicals, or exhibits hazardous chemical properties. Chapter 8 discusses numerous problems associated with the dual mixed waste regulatory authority of EPA and NRC.

[4] The annual limits were 200,000 cubic feet at Nevada, 1.2 million cubic feet at South Carolina, and 1.4 million cubic feet at Washington.

State Law Definitions

In contrast to federal policy, which explicitly addresses only volume reduction, Massachusetts policy is a preventive approach, directed at both the minimization of waste volume **and** the minimization of radioactive sources that result in the radioactive content of LLRW. The S/WVM-related definitions in Massachusetts LLRW management law are:

> Source minimization: "minimizing the volume of radioactivity of LLRW prior to its generation by such methods as: (1) avoiding unnecessary contamination of items during the use of radioactive materials; (2) carefully segregating radioactive waste from non-radioactive trash; or (3) substituting non-radioactive isotopes or radioisotopes[5] with shorter half-lives where practicable."
>
> Storage for decay: "a procedure in which LLRW with a relatively short half-life is held for natural radioactive decay in compliance with applicable federal and state regulations."
>
> Treatment: "any method, technique, or process, including source minimization, volume minimization and storage for decay, designed to change the physical, radioactive, chemical or biological characteristics or composition of LLRW in order to render such waste safer for management, amenable for recovery, convertible to another usable material or reduced in volume."
>
> Volume minimization: "treatment of LLRW after its generation in order to minimize the physical dimensions of the waste and the space required for disposal." [Chapter 111H, section 1]

The Massachusetts Department of Environmental Protection (DEP), which regulates mixed waste on the state level, defines "treatment" in similar terms to the "treatment" definition above. DEP regulations do not contain any "source minimization" definition. However, S/WVM is allowed for certain types of mixed waste, due to the exemptions that appear in the DEP definition of mixed waste. DEP regulations exempt from the definition of mixed waste:

(1) any waste oil that is radioactive, and

(2) any mixed waste that has been exempted by the NRC as being "below regulatory concern" (BRC). [310 Code of Massachusetts Regulations (CMR) 30.010]

In the case of (1), above, the DEP regulations exempt radioactive waste oil from all requirements of the hazardous waste regulations. The exemption allowed for (2) above excludes from the DEP mixed waste definition any mixed waste determined by the NRC to be BRC for purposes of regulating that waste as LLRW, but does not exempt the waste from regulations as hazardous waste. Because Congress outlawed the use by NRC of any BRC standard, the second DEP exemption is unnecessary.[6]

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[5] "Isotopes" are atoms of the same element which have different numbers of neutrons in the nucleus in combination with a fixed number of protons. "Radioisotopes" change from one atomic form to another through a spontaneous disintegration, or "decay" of the nucleus, releasing energy called radiation.

[6] Further discussion of the BRC issue and its implications for volume reduction can be found in section 10.7 of this chapter.

Factors Affecting S/WVM

The concept of waste minimization has gained momentum among LLRW generators ever since the passage of the federal LLRWPA in 1980, which assigns LLRW management responsibility to the states and sets deadlines for the development of state and regional LLRW disposal facilities. Waste generators realized the importance of volume reduction due to a concern that state disposal facilities would not be available to meet their disposal needs within the federally-mandated deadlines.[7]

In addition, ever-increasing costs of waste treatment, storage, transportation, and disposal have had significant impacts on volume reduction. Waste processing costs include expenditures for labor, equipment, supplies, and materials, which have all risen dramatically in the past decade. Transportation expenses are affected by rising fuel prices and changing requirements for packaging LLRW to ensure greater safety in transit.

Costs for disposal have increased by the greatest percentage. In 1977, the basic disposal charge at Hanford, Washington, was $2.65 per cubic foot. In 1991, that charge had escalated to $32.11. The 1985 LLRWPAA allows the three sited states, that were accepting the nation's waste at the time, to impose "surcharges" above their regular disposal fees. A portion of that surcharge is rebated to states to help fund their LLRW management efforts. Table 10-2 shows disposal fees between 1980 and 1994, and the additional surcharge.

Various market forces, including higher fuel prices, labor costs, and real estate values, continued to increase the costs of waste treatment, transportation, and disposal, and thereby contributed to greater LLRW minimization. However, the principal financial incentive that aided LLRW minimization was a result of action by the Southeast Compact Commission. After 1992, two of the states (Nevada and Washington) hosting commercial disposal sites closed their sites to the rest of the nation. Access to the one remaining state facility, at Barnwell, South Carolina, requires a contract with the Southeast Compact Commission and payment of a $220 per cubic foot surcharge. When the South Carolina site ceases to be available, individual states will be on their own to provide for LLRW management. Charges for centralized storage, treatment, and disposal are expected to remain high.

Another incentive for the move to waste minimization is the problem of dealing with mixed waste. Stringent requirements adopted by EPA in response to the 1985 amendments to the federal Resource Conservation Recovery Act (RCRA), has affected the availability of treatment and disposal capacity for mixed waste since that time.[8] Generators, therefore, have turned to various S/WVM/E techniques to avoid generating mixed waste, or to treat it and destroy the hazardous chemical properties so that the waste can be disposed of as LLRW.

Another important reason for an increase in S/WVM/E activities is public apprehension about any materials or waste that are "radioactive." Public reactions to accidents such as those at Three Mile Island and Chernobyl have fueled greater negativity towards the nuclear power industry, and have resulted in more intense concern over the generation, treatment, transportation, and disposal of both LLRW and high-level radioactive waste. A 1981 report by the NRC on the waste cleanup and disposal activities at Three Mile Island, Unit 2, indicated the NRC staff's concern over stresses to residents living along the waste disposal

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[7] The details of these mandates are described in Chapter 1.

[8] Envirocare of Utah, Inc. runs a landfill disposal site in Clive, Utah, for LLRW and mixed waste containing very small concentrations of certain radionuclides. It is the only disposal site in the nation to accept mixed waste for disposal. Because the Envirocare site is limited to the type of LLRW and mixed waste it can accept, its ability is limited to provide for all the mixed waste capacity needs in the country.

Table 10-2
Disposal Costs (Including Surcharges) at Three Commercial Sites
($ per cubic foot)

Year	S. Carolina	Nevada	Washington	Surcharge[1]
1980	$6.75	$7.40	$7.40	$0
1988	$27.62	$20.61	$25.04	$10[2]
1988	$35.32	$27.49	$29.60	$20[3]
1991-1992	$50.74*	$32.11	$32.11	$40[4]
1993-6/94	$50.74*	Site closed	$32.11	$220[5]

* = Average
[1] Surcharges are assessed on all users of the disposal sites. Generators from a state that has failed to meet certain explicit "milestones" mandated in federal law are obligated to pay penalties as follows:
[2] For failing the Jan. 1, 1986 milestone, double the surcharge to $20.
[3] For failing the Jan. 1, 1988 milestone, double the surcharge to $40 and quadruple the surcharge to $80 between July, 1988 and December, 1988.
[4] For failing the Jan. 1, 1992 milestone, triple the surcharge to $120. If disposal access is not available, 1/36th of the surcharge funds collected between Jan. 1, 1990 - Dec. 31, 1992 are to be rebated with interest to LLRW generators after 1992.
[5] A $220 per cubic foot surcharge applies only to shipments to Barnwell, South Carolina, from outside the Southeast Compact region. Massachusetts is one of the states that successfully executed a contract for access to Barnwell (through June 1994). As long as LLRW generators from Massachusetts have access to that site, they must pay the $220 per cubic foot premium. That surcharge is not mandated by federal law. Rather, it was adopted by the Southeast Compact Commission as a money-raising access fee.

Source: U.S. Department of Energy, disposal site operators, and Southeast Compact Commission, 1993.

transportation route.[9] The utility industry has responded by increasing its S/WVM/E activities.

These factors have encouraged LLRW generators, including most of those among the approximately 450 licensed radioactive materials users in Massachusetts,[10] to reduce volumes. The results of their efforts are substantial. Between 1980 and 1990, the amount of waste shipped for disposal dropped by 60%.[11] Table 10-3 shows the declining national and state volume totals. While Massachusetts generators shipped for disposal over 119,000 cubic feet in 1992 (see note in Table 10-3), data collected that estimated future generation rates indicates that by the mid-1990s, the total LLRW requiring disposal in licensed facilities will average between 20,000 and 25,000 cubic feet annually.

In addition, between 1984 and 1987, when 20 new nuclear powered reactors were constructed,

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[9] U.S. Nuclear Regulatory Commission. Final Programmatic Environmental Impact Statement Related to Decontamination and Disposal of Radioactive Wastes Resulting from March 28,1979 Accident - Three Mile Island Nuclear Station, Unit 2, NUREG-0683, Washington, DC, 1981.

[10] The number of licensed users of radioactive materials varies from time to time due to the expiration or termination of old licenses, and the issuance of new ones.

[11] Details of current Massachusetts LLRW generation and shipment for disposal can be found in the Management Board's annual survey reports. Further data on national trends is located in Chapter 4 of this volume.

Table 10-3 Volume Comparison Disposal at Three Commercial Sites, 1980–1992 (in cubic feet)		
Year	**Total National Volume**	**Total Massachusetts Volume**
1980	3,768,875	221,225
1981	3,098,669	303,121
1982	2,678,952	285,895
1983	2,707,581	166,828
1984	2,662,644	192,879
1985	2,681,970	105,544
1986	1,804,999	66,695
1987	1,844,504	55,023
1988	1,429,016	51,273
1989	1,627,813	56,527
1990	1,142,810	40,613
1991	1,369,303	2,686
1992	1,743,279	56,734

Note: The significant reduction that occurred in the mid-1980s was partially due to the availability of improved treatment technologies, such as supercompaction and incineration. None of the national volume totals include the amounts of LLRW shipped each year to Envirocare. An unusually high volume of LLRW was shipped by Massachusetts generators to the Utah site in 1992, due to a number of decommissioning activities. If the amount sent to Envirocare (60,486) were included in the 1992 Massachusetts total, it would increase to 119,004 cubic feet.

Source: U.S. Department of Energy.

LLRW volume produced by the nuclear power industry and shipped for disposal dropped 42%.[12]

While efforts to reduce LLRW volumes have been highly successful, efforts to minimize the amount of radioactivity of LLRW shipped for disposal have not. Table 10-4 shows the total activity of the waste disposed of at Beatty, Nevada; Barnwell, South Carolina; and Hanford, Washington, from the years 1986 through 1992. The significant increases in curies disposed of in 1986, 1991, and 1992 appear to be directly related to the milestones of the federal LLRWPAA. Because of the surcharge that took effect in 1986, generators in 1985 may have hastened to ship for disposal all LLRW accumulating on site, including high curie-content waste removed from the nuclear power plants, before the surcharge increased disposal costs. Similarly, in 1989, 1991, and 1992, generators removed larger volumes of cyclical utility plant waste, with higher curie contents, to avoid surcharge increases, and to dispose of waste prior to the closure of some disposal sites.

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[12] U.S. Congress, Office of Technology Assessment, Partnerships Under Pressure: Managing Commercial Low-Level Radioactive Waste, OTA-O-426, Washington, DC, November, 1989.

Table 10-4 LLRW Activity Comparison, 1986-1992 (in curies)							
	1986	1987	1988	1989	1990	1991	1992
National Total	233,740	269,550	259,661	856,900	547,902	799,875	1,000,102
Massachusetts	8,790	1,552	10,070	57,306	111,082	32,531	76,588

Note: The "National Total" reflects the radioactivity of LLRW shipped to Beatty, Nevada; Barnwell, South Carolina; and Hanford, Washington. The Massachusetts data excludes the radioactivity of LLRW shipped to Envirocare of Utah, which totaled 2.4 curies in 1992.

Source: U.S. Department of Energy.

Adverse Effects of S/WVM/E Policy

While source and volume minimization and elimination are beneficial objectives, there are potential negative impacts associated with these concepts. For example:

- making a process change to reduce or eliminate radioactive materials use can result in increased chemical toxicity if the process has substituted toxic chemicals for radioactive materials. As discussed in the risk assessment section of Chapter 3, the hazards associated with toxic chemical waste can be far greater than those associated with LLRW.

- reducing the volume of waste for disposal can result in higher average occupational radiation doses to employees of the waste generator or employees of the disposal facility. This is due to the fact that volume reduction methods, such as incineration or compaction, do not reduce the total radionuclide content of the waste; instead, they concentrate the radioactivity in smaller packages. Depending upon how the waste is packaged, surface radiation could increase. In addition, extra waste handling necessary for volume reducing treatments can increase occupational exposure.

As radioactive materials users consider new S/WVM/E techniques, it will be important for them to evaluate the relative hazard potentials of alternative waste forms, to improve waste handling practices by employees, and to provide training and better personnel radiation shielding for their radiation workers' protection.

The problems associated with S/WVM/E are not great enough to abandon these policies. However, it is important to understand that reducing or eliminating radioactive sources and minimizing or eliminating LLRW are not necessarily simple tasks, and that complex trade-offs are involved in designing and implementing such policies.

10.3 Source and Waste Volume Minimization/Elimination Procedures

The most frequently practiced minimization methods are those involving volume reduction. From the simplest volume reduction example of storing for decay LLRW that contains short half-life material, to complicated volume reduction methods such as chemical regeneration for the treatment of spent ion exchange resins (described later in this chapter), users of radioactive materials have had more successful

experience with volume reduction techniques than they have had with source reduction methodologies.

However, radioactive materials licensees need to incorporate all practical methods to avoid generating the waste, as well as minimizing the volumes produced. There are societal benefits to avoiding LLRW generation, as well as economic benefits to the generator. For society, less waste produced means less waste requiring disposal, whether or not the waste is further volume-reduced. Less waste means reduced chances of harm to public health or the environment, and less burden on the public to pay for costly mitigation, decontamination, and decommissioning in the future.

For the generator of LLRW, reducing or eliminating the sources of waste means less handling and packaging, more space available for waste storage, and reduced costs for disposal.

A generator's S/WVM/E effort should focus on four areas:[13]

(1) Administrative policies and procedures;

(2) Design and engineering/equipment;

(3) Operation and maintenance; and

(4) Decontamination and decommissioning.

Administrative Policies and Procedures

Administrative efforts to accomplish S/WVM/E involve both the technical systems and the human employee organizations of the radioactive materials user. They encompass every phase of company activity, from construction (layout and "zoning" control) to waste-handling during company operation, to future decision-making.

Administrative controls should begin with a clear policy statement in support of source reduction/elimination. The policy should be issued from the chief executive officer and include specific goals and implementation strategies for department managers and subordinate workers.

Some areas where administrative controls can be effective include:

Contamination control: Administrative policies and procedures to prevent radiation from contaminating non-radioactive equipment and materials involve setting accurate guidelines, analyzing recorded data, and involving the appropriate personnel. These are accomplished through radiation control zoning and waste-handling practices.

Regulations of the NRC govern the areas in a company or institution where radioactive materials can be used, the dose limits allowed in such areas, and the "control zones" (e.g., access points to radiation areas that contain devices such as alarms to alert employees as they enter radiation areas, and which allow for decontamination as workers leave radiation areas). [10 Code of Federal Regulations (CFR) Part 20] The areas designated for control zones can affect the generation of LLRW, by ensuring that workers are decontaminated and that they leave contaminated tools behind, before moving to another area of the plant.

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[13] The discussion of these items has been modified from the report, Low-Level Radioactive Waste Management Handbook Series: Methods to Decrease Low-Level Waste Generation, 1982, prepared by DOE's National Low-Level Radioactive Waste Management Program.

Distinguishing between areas of potential high and low contamination is another way of administratively providing contamination control. Personnel monitoring equipment that measures the radiation dosage of each worker, and use of protective clothing, may vary, depending upon need in the high- and low-contamination areas.

Waste-handling: Sloppy or inappropriate waste-handling practices can produce LLRW. Administrative policies and procedures should be developed to require workers who handle waste to be responsible for preparing the paperwork required for storage or disposal procedures.

Materials segregation: Because most radioactive materials users produce several different types of waste streams, the segregation of radioactive materials prior to their generating waste will help avoid or reduce LLRW waste generation. Administrative procedures can ensure proper segregation.

Storage for decay: A policy to ensure that all short-lived radionuclides are stored for decay on site, rather than shipped off site for disposal, should be published for all employees, and written reminders should be routinely distributed.

Training: Administrative processes should be implemented to ensure that radioactive materials are not handled by anyone other than certified or approved personnel trained in source reduction or elimination techniques.

Records and audits: Accurate records provide a baseline for evaluating the effectiveness of various practices aimed at S/WVM/E.

Charging for waste generation: Volume reduction incentives can be accomplished through policies that charge waste storage and disposal costs directly to the department or function that generated the waste, rather than assigning it to "overhead."

Design and Engineering/Equipment

LLRW production can be minimized by using sound design and engineering practices during the planning and construction of the company's or institution's facility. Some of the areas where design and engineering can be effective include:

Contamination control: Identifying sources of potential contamination during the facility design stage can enable planning of proper construction materials, monitoring equipment, isolating equipment, and materials such as coatings or mats that prevent contamination.

Equipment: Pieces of machinery that will become contaminated should be isolated from those pieces that do not require direct contact with radiation sources. Remote operations, or removable compartmentalized equipment, should be incorporated into plant design.

Isolating contamination areas: Design and layout of radiation areas should include personnel monitoring areas to reduce the spread of contamination to other parts of the facility. Proper ventilation system design can aid contamination control.

Reuse of equipment: Recycling protective clothing by laundering and using personal radiation detection devices to prolong the periods between washings can help reduce a large portion of dry compactible wastes. Recycling process streams (such as ion exchange materials) can reduce waste requiring disposal.

Equipment decontamination: If possible, equipment should be designed to be decontaminated for

reuse, thereby avoiding disposal.

Reusable material storage: Plant design should provide for areas within control zones to store reusable items, such as contaminated tools. Storage areas should be located in convenient places, to encourage their use.

Storage for decay: Plant design should incorporate sufficient space to store contaminated items (waste, tools, equipment, etc.) for decay if contaminated by short-lived radionuclides.

Isolation from sources of radiation: Plant design should isolate equipment from sources of radiation to reduce the number of contaminated items of equipment requiring disposal. Automated equipment can reduce radiation exposure to plant workers.

Process planning: Designing processes that incorporate reduced usage of radionuclides or substitute non-radioactive materials for radioactive ones can aid in source minimization and elimination. "Process dynamics must be understood in order to maintain optimum process conditions. Operator efficiency and reliability affect LLRW generation. Untrained persons require closer supervision and instruction as well as more elaborate facilities."[14]

Waste treatment: Plant design should include waste treatment so that treatment methods are used not only to process waste but also to maintain efficiency of operation.

Operation and Maintenance

Activities during operation and maintenance can minimize or eliminate the sources generating LLRW and waste volumes. Some areas that can be effective include:

Contamination control: Maintenance of systems or equipment that become contaminated can often be decontaminated, rather than disposed of, by covering surfaces with plastic, strippable paint, or other materials that can reduce the amounts of contaminated material generated during maintenance. Using alternatives other than organic chemicals to clean radioactively contaminated equipment can avoid the generation of mixed waste.

Good "housekeeping" practices: Controlling the purchases of radioactive materials to avoid "overpurchases" and optimize inventory control can eliminate waste generation from unused source materials.

Scheduling: Maintenance activities should be planned to occur during offshift periods or holidays.

Equipment repair: Repairing equipment for reuse rather than replacement can reduce LLRW generation. However, repair should be evaluated against such factors as (1) the production of other wastes (hazardous or solid); (2) the potential for greater radiation exposure during repair; (3) added decontamination wastes; (4) time and repair costs; and (5) replacement with superior parts or equipment.

Proper equipment operation: The proper functioning of equipment will reduce wastes generated from failures or upsets in process. Reducing equipment "downtimes" can lower the amount of LLRW requiring disposal.

Remote monitoring: Monitoring devices that do not require sampling by workers will reduce wastes

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[14] Ibid.

that would come from "wipe tests" or physical sampling.

Operations analysis: Operating conditions should be analyzed to identify and reduce radiological hazards. Non-radioactive materials or those with shorter half-lives should be substituted where possible.

Training: Operations and maintenance employees should be fully familiar with procedures that can reduce LLRW generation. Repeat training programs can ensure better employee understanding and implementation.

Preventative maintenance: Preventative maintenance can reduce the generation of LLRW by avoiding serious equipment damage and reducing the frequency of unscheduled downtime.

Contractor responsibilities: Contractors hired to work inside contamination areas should be responsible for disposing of any waste they produce. This policy will act as an incentive to keep contractor-generated waste to a minimum.

Written Operation and Maintenance (O and M) procedures: Manuals and other written O and M practices, which provide clear instructions for personnel, will help ensure the continuation of procedures that facilitate eliminations or reductions in LLRW generation.

Decontamination and Decommissioning

Decontamination means the removal of radioactive material from surfaces such as building walls and floors, tools and equipment, or from fluids. Decommissioning means to remove safely from service an activity involving radioactive materials or waste, so that residual radioactivity can be reduced to a level that permits release of the property for unrestricted use as well as termination of the radioactive materials user's license. Decontamination is one aspect of decommissioning.

Decontamination methods can be developed to reduce radiation exposure, lower the amount of waste requiring disposal, and extend the life of plant equipment. Some areas where decontamination can be effective include:

Evaluate decontamination processes: Determine what type of decontamination method results in the lowest amount of waste. Methods include:

- mechanical decontamination: vacuuming, scrubbing, and then absorbing liquid (or soaking and absorbing); high-pressure steam and water cleaning; abrasive decontamination (sand blasting, planing down surfaces, etc.);

- chemical decontamination: use of specific chemicals (solvents, acids, etc.), followed by rinsing; and

- special decontamination: ultrasonic cleaning, electropolishing, or freon cleaning.

Contamination control: Methods of controlling contamination can reduce the time, labor and materials necessary for decontamination.

Equipment reuse: Recycling materials and equipment may produce waste generated during decontamination, and should therefore be compared with the disposal cost and volume of contaminated materials and equipment, before considering their recycling.

Decontamination of process streams: Reusing process streams through decontamination can

prevent waste production.

Selecting decontamination cleaning solutions: Cleaning agents (solvents, detergents, etc.) should not produce mixed waste.

While decommissioning will necessarily produce additional quantities of waste, the outcome of eliminating future LLRW generation and enabling the property to be available for unrestricted use has a positive overall S/WVM/E result.

Chapter 14 details decommissioning activities for all types of radioactive materials users, ranging from the smallest LLRW generators to the nuclear-powered electric generating plants.

10.4 Waste Volume Reduction by Storage for Decay

Because a large portion of the waste produced in Massachusetts contains radionuclides with relatively short half-lives,[15] it can be stored on site to decay to safe radiation levels within the storage period allowed by the NRC, and then disposed of with other solid wastes. Radioactive materials and LLRW with half-lives of 65 days or less can be stored for decay under current NRC guidelines. Materials and waste containing radionuclides with half-lives of up to 120 days can be stored for decay with proper justification to the NRC. A list of the short-lived radionuclides commonly in use in Massachusetts appears in Table 10-5.

Once the radioactivity has decayed to safe, background levels, the waste is no longer considered LLRW but is, instead, solid waste that can be disposed of like other non-hazardous household and industrial trash.

The NRC allows licensed users of radioactive materials to store those materials (including amounts contained in LLRW) for a period not exceeding the length of the license. Most licensees are licensed for a three-year period, and are therefore eligible to store radionuclides for decay up to three years. The NRC allows storage for a maximum period of five years. Chapter 12 provides additional details on NRC's storage policies and license requirements.

A radioactive materials user's ability to store for decay is also limited by the on-site storage space available.

Packaging requirements to store LLRW for decay are not explicitly established in the NRC regulations. However, the 10 CFR Part 20 limits on radiation levels permitted in "restricted areas" (from which the public would be excluded), including storage for decay areas, require certain types of packaging to be met.

NRC Storage Notice

In February, 1990, the NRC issued an "Information Notice" to all LLRW generators, urging them to make necessary preparations for on-site storage of LLRW if no disposal capacity was available after December, 1992. (As noted earlier in this chapter, this was the date when the states controlling three commercial LLRW disposal sites were allowed by federal law to deny access to LLRW generators across

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[15] The "half-life" of a radioactive substance is the time in which half of the atoms disintegrate to another nuclear form.

Table 10-5
Radionuclides That Can Be Stored for Decay
Commonly Used in Massachusetts

Radionuclide	Half-life	Radionuclide	Half-life	Radionuclide	Half-life
Indium-11	72s	Gallium-67	3.[illegible]	Ruthenium-103	39.3
Gallium-68	68m	Dysprosium-166	3.4	Iron-59	45
Nickel-65	2.5h	Rhenium-186	3.8	Mercury-203	46.6
Technetium-99m	0.3	Xenon-133	5.2	Indium-114m	49.5
Lead-201	0.4	Gold-196	6.2	Strontium-89	50.5
Iodine-123	0.6	Iodine-131	8	Beryllium-7	53.3
Bromine-82	[illegible].6	Thallium-202	12.2	Antimony-124	60.2
Lanthium-140	1.7	Barium-140	12.7	Technetium-95m	61
Lead-203	2.2	Phosphorous-32	14.3	Zirconium-95	64
Yttrium-90	[illegible].4	Rubidium-86	18.7	Strontium-85	64.8
Gold-198	[illegible].4	Chromium-51	27.8	Cobalt-58	70.8
Molybdenum-99	2.8	Ytterbium-169	32	Iridium-192	74
Indium-111	[illegible].4	Cerium-141	32.4	Scandium-46	5[illegible].5
Thallium-201	3	Niobium-95	35.2	Sulfur-35	87.2

s=seconds; m=minutes; h=hours; undesignated=days

Source: Massachusetts Low-Level Radioactive Waste Management Board.

the nation.) The NRC information document relates to storing **all** waste on site for an interim time period (i.e., waste that can be stored for decay within the allowable storage time period, as well as waste that will still require disposal after the allowable storage period ends).

The NRC Information bulletin emphasizes that its licensing regulations allow on-site storage for only five years or less. Because most licensees in Massachusetts are licensed to possess radioactive materials for only three years, the Massachusetts Board has urged licensees to seek amendments to their radioactive materials "possession limits" so that they can store radioactive materials and LLRW for up to five years once disposal capacity is unavailable.

The NRC interim storage Information Notice makes the following general recommendations that apply to storage for decay:

- Stored waste should be shielded from the elements and from extremes of temperature and humidity to ensure package integrity and the maintenance of waste form (e.g., solid, liquid, or gaseous waste).

- Waste should be stored in an area that allows for routine visual inspection and radiation monitoring.

- Licensees should evaluate what wastes they plan to store, and take measures to prevent decomposition or chemical reaction from "incompatible" waste materials over time.

- Licensees should store waste in a manner that ensures no potential increase in direct radiation exposure to workers above the limits established in 10 CFR Part 20.

- Stored waste should be placed in a "restricted" area and locked to prevent unauthorized access.

- Inventory records of waste types, contents, and dates of storage should be maintained.

Mixed Waste Storage for Decay

Storage for decay of mixed waste can be a problem, due to regulations that implement the 1985 amendments to the Resource, Conservation and Recovery Act (RCRA) (the Hazardous and Solid Waste Amendments Act - HSWA).

Under RCRA regulations and those of the DEP, a permit is necessary to store any mixed waste for 90 days or longer unless the generator produces less than 220 pounds each month of all types of hazardous waste.[16] However, under **other** RCRA and DEP regulations, mixed wastes that contain hazardous wastes prohibited from land disposal without treatment **cannot be stored** at all, "except to accumulate sufficient quantities to enable proper recovery, treatment or disposal." [40 CFR 268.50] Because little licensed treatment capacity exists in the nation to handle mixed waste, with the exception of liquid scintillation fluids, and little disposal capacity is available, generators cannot legally use storage for decay to minimize mixed waste volumes.

Chapter 8 describes the numerous mixed waste regulatory problems, including storage for decay.

The State's Storage for Decay Policies

Storage for decay is identified in the Massachusetts LLRW management act as a form of S/WVM. Chapter 111H requires DPH to establish, by regulation, a waste minimization program that includes storage for decay. The statute also requires the Management Board to recommend minimization policies and procedures for use by DPH in developing its regulations for source minimization, volume minimization, and storage for decay. The Management Board's recommendations appear in Appendix 10A of this chapter.

In Massachusetts, storage for decay is a major technique for treating LLRW by eliminating the radioactivity of the waste. Of the 152,292 cubic feet of total waste produced in Massachusetts in 1991, and the 349,392 cubic feet produced in 1992, 38,219 and 41,229 cubic feet, respectively, did not have to go to disposal facilities because it decayed to safe levels of radioactivity, allowing disposal of this waste as ordinary solid waste.

Storage for decay is especially useful to hospitals and medical research facilities, which use primarily short-lived materials. As a result of this radioactivity-eliminating technique, most hospitals in Massachusetts

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[16] RCRA regulations allow generators who produce between 200 and 2,200 pounds of hazardous waste each month (including mixed waste) to store the waste on site for up to 180 days without a storage permit as long as the total hazardous waste stored does not exceed 13,200 pounds. The 180-day limit can also be extended to 270 days under certain circumstances. As noted, however, these brief time periods do not enable generators to store mixed waste for decay except waste containing **very** short-lived nuclides (i.e., half-lives less than two days).

do not have to send their LLRW to licensed disposal facilities.

Table 10-6 lists all Massachusetts hospitals, licensed to use radioactive materials, and the volumes of waste they generated before and after using storage for decay and other treatment prior to disposal.

Most Massachusetts LLRW generators use the storage for decay technique at the site of waste production. However, some consolidated or shared storage for decay also occurs. For instance, Harvard University uses two state-of-the-art buildings at its Southboro campus to store for decay LLRW generated in laboratories that are covered under the university's radiation protection program. These include labs at Harvard University and the Harvard Medical School affiliated institutions, which provide research for university-affiliated programs and hold Harvard appointments.[17] In addition, several commercial licensees that have divisions in more than one location may consolidate their storage activities at one site.

Table 10-6
Massachusetts Hospitals and Medical Centers
Average of 1991 and 1992 Volumes Before and After Treatment
(Including Storage for Decay)
(cubic feet)

Hospital or Medical Center	Before Treatment	After Treatment
Addison Gilbert Hospital, Gloucester	14.5	0.0
Amesbury Hospital, Amesbury	6.0	0.0
Anna Jaques Hospital, Newburyport	10.0	0.0
AtlantiCare Medical Center, Lynn	53.3	3.3
Baystate Medical Center, Springfield	128.0	0.0
Berkshire Medical Center, Pittsfield	500.0	0.0
Beth Israel Hospital, Boston	1,632.9	37.4
Beverly Hospital, Beverly	2.0	0.0
Boston City Hospital, Boston	249.9	100.7
Boston University Medical Center., Boston	1,012.0	296.5
Brigham & Women's Hospital, Boston	2,520.2	35.4
Brockton Hospital, Brockton	100.0	0.0
Burbank Hospital, Fitchburg	126.9	0.0
Cambridge Hospital, Cambridge	0.0	0.0

[17] The Harvard University and Harvard Medical School affiliated institutions include: Massachusetts General Hospital, Brigham and Women's Hospital, Beth Israel Hospital, Children's Hospital, Dana Farber Cancer Institute, McLean Hospital, Forsyth Dental Center, Eunice Kennedy Shriver Center, Faulkner Hospital, The Center for Blood Research, Joslin Diabetes Center, Spaulding Rehabilitation Hospital, Boston Biomedical Research Institute, Eye Research Institute, and Jewish Rehabilitation Hospital. LLRW generated at these locations but not managed by the Harvard program is shipped for disposal, generally by brokers, directly from these institutions.

Table 10-6
Massachusetts Hospitals and Medical Centers
Average of 1991 and 1992 Volumes Before and After Treatment
(Including Storage for Decay)
(cubic feet)
(continued)

Hospital or Medical Center	Before Treatment	After Treatment
Cameo Diagnostic Center, Inc., Springfield	30.5	30.4
Cape Cod Hospital, Hyannis	100.0	0.0
Cardinal Cushing General Hospital, Brockton	6.0	0.0
Carney Hospital, Dorchester	30.5	0.0
Charlton Memorial Hospital, Fall River	100.0	0.0
Children's Hospital, Boston	1,482.2	39.4
Cooley Dickenson Hospital, Northhampton	6.0	0.0
Dana-Farber Cancer Institute, Boston	2,571.5	14.6
Emerson Hospital, Concord	52.5	0.0
Eunice Kennedy Shriver Center, Waltham	13.9	0.8
Eye Research Institute of Retina Foundation, Boston	293.0	0.0
Fairview Hospital, Great Barrington	30.5	0.0
Falmouth Hospital, Falmouth	100.0	0.0
Faulkner Hospital, Jamaica Plain	30.8	0.0
Franklin Medical Center, Greenfield	6.3	1.0
Glover Memorial Hospital, Needham	4.5	0.0
Goddard Memorial Hospital, Stoughton	5.0	0.0
Hale Hospital, Haverhill	35.1	0.0
Harrington Memorial Hospital, Southbridge	8.0	0.0
Henry Heywood Memorial Hospital, Gardner	7.5	0.0
Hillcrest Hospital, Pittsfield	5.0	0.0
Holy Family Hospital and Medical Center, Methuen	97.4	0.0
Holyoke Hospital, Holyoke	118.0	0.0
Hunt Center for Emergency and Ambulatory Care, Danvers	168.5	0.0
J B. Thomas Hospital, Peabody	12.3	0.0
Jordan Hospital, Plymouth	24.0	0.0
Joslin Diabetes Center, Boston	934.3	7.5
Lahey Clinic Medical Center, Burlington	77.5	0.0

Table 10-6
Massachusetts Hospitals and Medical Centers
Average of 1991 and 1992 Volumes Before and After Treatment
(Including Storage for Decay)
(cubic feet)
(continued)

Hospital or Medical Center	Before Treatment	After Treatment
Lawrence General Hospital, Lawrence	13.0	0.0
Lawrence Memorial Hospital of Medford, Medford	47.5	0.0
Leominster Hospital, Leominster	11.3	0.0
Lowell General Hospital, Lowell	6.0	0.0
Ludlow Hospital, Ludlow	7.5	0.0
Malden Hospital, Malden	0.0	0.0
Marlborough Hospital, Marlborough	10.5	0.0
Martha's Vineyard Hospital, Oak Bluffs	7.5	0.0
Massachusetts Eye & Ear Infirmary, Boston	131.8	0.8
Massachusetts General Hospital, Boston	4,758.8	24.2
Medical Center of Central MA (Memorial), Worcester	10.5	0.0
Medical Center of Central MA (Hahneman), Worcester	6.0	0.0
Melrose/Wakefield Hospital, Melrose	75.0	0.0
Mercy Hospital, Springfield	0.0	0.0
Milford-Whitinsville Regional Hospital, Milford	7.5	0.0
Milton Hospital, Milton	7.5	0.0
Morton Hospital and Medical Center, Taunton	25.0	0.0
Mt. Auburn Hospital, Cambridge	131.8	0.0
Nashoba Community Hospital, Ayer	12.0	0.0
New England Baptist Hospital, Boston	6.0	0.0
New England Deaconess Hospital, Boston	789.9	366.1
New England Medical Center, Boston	769.6	193.7
New England Memorial Hospital, Stoneham	7.5	0.0
Newton-Wellesley Hospital, Newton	7.5	0.0
Noble Hospital, Westfield	5.0	0.0
North Adams Regional Hospital, North Adams	14.0	0.0
Norwood Hospital, Norwood	100.0	0.0
Quincy City Hospital, Quincy	75.0	0.0

Table 10-6
Massachusetts Hospitals and Medical Centers
Average of 1991 and 1992 Volumes Before and After Treatment
(Including Storage for Decay)
(cubic feet)
(continued)

Hospital or Medical Center	Before Treatment	After Treatment
Salem Hospital, Salem	37.5	0.0
Somerville Hospital, Somerville	0.0	0.0
Sancta Maria Hospital, Cambridge	0.0	0.0
South Shore Hospital, South Weymouth	100.0	0.0
Southwood Community Hospital, Norfolk	27.0	0.0
Spaulding Rehabilitation Hospital, Boston	12.5	0.0
St. Anne's Hospital, Fall River	0.0	0.0
St Elizabeth's Hospital, Boston	55.5	0.0
St John's Hospital, Lowell	100.0	0.0
St Joseph's Hospital, Lowell	53.5	0.0
St Luke's Hospital, New Bedford	112.5	0.0
St. Luke's Hospital, Middleboro	80.0	0.0
St. Margaret's Hospital for Women, Dorchester	0.0	0.0
St Vincent Hospital, Worcester	23.5	0.0
Sturdy Memorial Hospital, Attleboro	0.0	0.0
Symmes Hospital, Arlington	15.0	0.0
Tobey Hospital, Wareham	50.0	0.0
V A Medical Center, Boston, Boston	89.7	7.6
V A Hospital (ENRM), Bedford	80.8	0.8
VA Hospital Northhampton, Northampton	2.5	0.0
Waltham/Weston Hospital and Medical Center, Waltham	0.0	0.0
Whidden Memorial Hospital, Everett	39.0	0.0
Winchester Hospital, Winchester	21.6	0.0
Wing Memorial Hospital, Palmer	50.0	0.0
Winthrop Hospital, Winthrop	15.0	0.0
Total	20,708	1,165

Source: Massachusetts Low-Level Radioactive Waste Management Board. 1991 and 1992 Massachusetts Low-Level Radioactive Waste Survey Reports. November, 1992, and October, 1993.

10.5 Other Volume-Reduction Technologies

In addition to storage for decay, there are a number of other volume-reduction technologies used to minimize waste generated. As has been noted in the discussion of storage for decay, volume reduction decisions are dependent upon the physical and chemical characteristics of the waste, its radionuclide content, and specific activity as well as standards affecting its packaging, transportation, and disposal.

LLRW is produced in four physical forms: liquids, wet solids, dry solids, and gases. When treated through various reduction technologies, gaseous wastes can be transformed to one of the other three forms. Each of these forms of waste may contain chemical characteristics that classify it as mixed waste.

Table 10-7
Forms of Massachusetts LLRW

	Percentage
Solids	93.5
Liquids	0.5
Wet Solids	6.0
Gases	0

The percentages shown above are based on the form of the 1992 LLRW generated in Massachusetts. These percentages remain fairly constant from year to year.

Source: Massachusetts Low-Level Radioactive Waste Management Board. 1992 Massachusetts Low-Level Radioactive Waste Survey Report. October, 1993.

Massachusetts LLRW is generated in all four forms, and Table 10-7 shows the approximate annual percentages of each. The greatest percentage falls into the dry solid category. Dry solids include clothing, paper products, rags, plastics, construction materials, piping, safety goggles, tools, ventilation filters, soil, pumps, valves, pipes, and irradiated hardware.

Liquid wastes in Massachusetts LLRW include liquid scintillation vials, chemical regenerative solutions produced at nuclear power plants, solutions used for decontamination, contaminated oils, and laundry and rinse water wastes. Wet solids are usually in "slurry" form, and include evaporator bottoms, filter media, spent ion-exchange wastes, and biological wastes such as animal carcasses, tissues, animal bedding, and biological cultures. In general, liquid and wet solid wastes cannot be packaged for transportation and disposal in their as-generated form without the use of absorbents or solidification, due to requirements of the NRC and U.S. Department of Transportation (DOT).

Numerous volume-minimization technologies are available to treat LLRW. Those in use are identified in Table 10-8 and are briefly described in the paragraphs that follow.

Compaction and Supercompaction. Compaction is one of the easiest and most effective techniques in use to reduce dry solid LLRW. Compaction physically compresses the waste material into a smaller volume. Depending upon the type of compaction, a machine can exert a force ranging from 10 tons (older, conventional compactors) to 5,000 tons (supercompactors).

Some compactors compress the waste directly into 55-gallon drums. Box compactors can compress larger objects into rectangular-shaped containers at forces up to 250 tons. Supercompactors, also known as high-pressure compactors, are so powerful that they can compress metal LLRW into the final disposal container.

The efficiency of any compactor in reducing volume depends upon the force applied, the density of the waste, and the characteristic of the waste to "spring back" to its old size after the compaction pressure is released. Anti-spring-back mechanical devices have been developed, which lock the compacted

Table 10-8 Waste Minimization Technologies and Practices				
Technology	Waste Forms			
	Dry Solids	Liquids	Wet Solids	Gases
Compaction	X	–	–	X
Supercompaction	–	–	–	–
Segregation	X	X	X	–
Shredding	X	–	–	–
Incineration	X	X	X	X
Filtration	–	X	X	X
Ion Exchange	–	X	–	–
Evaporation	–	X	–	–
Crystallization	–	X	–	–
Flocculation	–	X	–	–
Precipitation	–	X	–	–
Sedimentation	–	X	X	–
Centrifugation	–	X	X	–
Drying	–	–	X	–
Dewatering	–	X	X	–
Return to Manufacturer	X	–	–	–
Recycling	–	X	X	X

Source: Modified from U.S. Department of Energy. Low-Level Radioactive Waste Treatment Technology. DOE/LLW-13Tc. National Low-Level Radioactive Waste Management Program, Idaho Falls, ID, July, 1984.

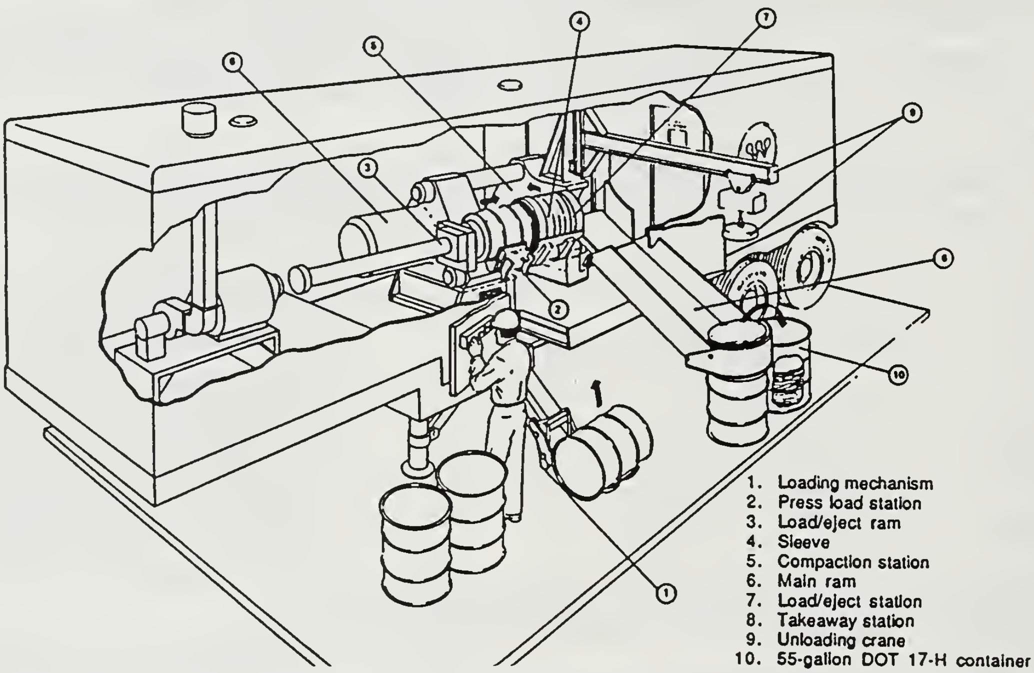
material in place and prevent it from refilling the container. In addition, shredding the waste material can improve its compactibility.

Two commercial supercompaction facilities used by Massachusetts LLRW generators are operated by Scientific Ecology Group (SEG) and Quadrex; both are located in Tennessee. The SEG facility reduces uncompacted dry solid wastes by a factor of 5, and pre-compacted dry solid waste volumes by a factor of 2.

Figures 10-A and 10-B illustrate a mobile supercompactor and a conventional compactor.

Segregation. Waste segregation can achieve significant decreases in the volume ultimately requiring disposal. Workers frequently discard paper, cloths, and other waste products as radioactive waste, when these materials are not contaminated with radioactive substances, because it is easier to throw all waste into one container than to segregate the waste into that which is radioactive and that which is not. This can be a major problem in research laboratories and among other categories of radioactive materials users where personnel may work with radioactive isotopes containing both short and long half-lives. By segregating

Figure 10-A
Mobile Supercompactor



Source: National Low-Level Radioactive Waste Management Program. Low-Level Radioactive Waste Volume Reduction and Stabilization Technologies Resource Manual, DOE/LLW-76T. Idaho Falls, ID, December, 1988.

short-lived from longer-lived waste, significant reductions in LLRW volume can be achieved.

Sorting and separation of non-radioactive materials that were combined with radioactive materials during a specific process is also a significant volume minimization practice.

Shredding. Paper, cloth, plastics, and some light metals can be shredded into smaller pieces to aid in compaction and incineration. Shredders contain a series of intermeshing, counter-rotating shafts driven by a motor to slice the waste for additional volume minimization.

Incineration. Incineration can achieve waste volume minimization factors ranging from 30:1 to 100:1 before final ash immobilization and packaging. After packaging, the volume reduction continues to be up to five times greater than any other minimization technology, including supercompaction.

Incinerators have been in use since the 1950s, but today's incineration systems have little similarity to the earlier models, except that they all burn waste. The newest incineration systems are more successful in controlling emissions, including radionuclides, acid gases, heavy metal compounds, and toxins, at emission levels that are much lower than those occurring at existing fossil-fueled or waste-fueled power plants.[18]

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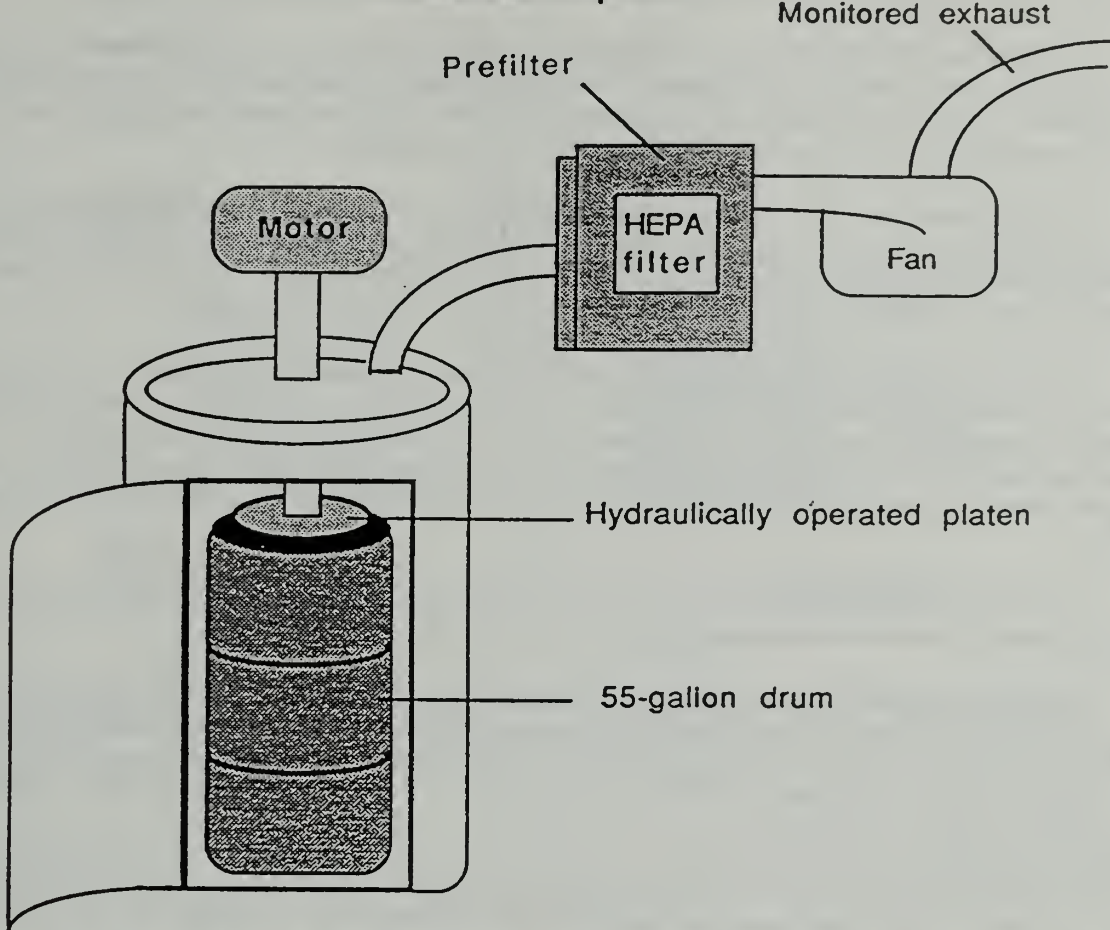
[18] Long, S. The Incineration of Low-Level Radioactive Waste. (Report for the Advisory Committee on Nuclear Waste). NUREG-1393. U.S. Nuclear Regulatory Commission, Washington, DC, June, 1990.

Figure 10-B
Conventional Compactor



Source: National Low-Level Radioactive Waste Management Program. Low-Level Radioactive Waste Volume Reduction and Stabilization Technologies Resource Manual. DOE/LLW-76T. Idaho Falls, ID, December, 1988.

Incineration can minimize dry solid, liquid, wet solid, and gaseous wastes. There are two resulting by-products: one is called a "bottom-ash," and the second a "fly-ash." The bottom-ash is the radioactively contaminated waste that remains after the burning process; the fly-ash is produced and captured as part of the off-gas particulate matter (i.e., stack residues). Both ashes can be mixed with glass, cement, concrete, or other materials to ensure stability.

Incineration has been used extensively by hospitals and research institutions across the country, initially to dispose of infectious biological wastes and then later to volume-reduce their LLRW. A survey of medical users in 1979 indicated that about one-third of the medical facilities nationally were incinerating a portion of their LLRW. The waste treatment practices of hospitals and medical research institutions in Massachusetts are similar to those nationwide. According to the Management Board's annual survey, about 15 of the hospitals and medical research institutions in the Commonwealth use incineration to minimize their waste.

Incineration can destroy some organic hazardous wastes and PCBs regulated under RCRA and the federal Toxic Substances Control Act (TSCA). It can therefore convert some mixed waste into LLRW, leaving ash that can be solidified further for disposal in a licensed LLRW disposal facility.

The advantages of incineration over other waste treatment technologies include the significant volume reductions achieved, the elimination of toxic chemicals in mixed waste, and the creation of stable waste forms. The disadvantages include concerns about risk of environmental and public health damage from the release to the atmosphere of toxic and radioactive gases.

Some radioactive materials users in Massachusetts have small on-site incinerators that are used to burn de minimis quantities of radioactive waste under an NRC rule that allows "exempt quantities" to be managed without disposal in a licensed LLRW disposal facility (see section 10.7 of this chapter). Some Massachusetts hospitals and research institutions use incineration in this manner.

Out-of-state commercial incinerators also are utilized by some Massachusetts LLRW generators, especially those generators that produce large volumes of LLRW. One such facility, owned by SEG in Oak Ridge, Tennessee, handles large volumes from the Commonwealth and the rest of the nation. The SEG Incinerator was permitted and began operation in October, 1989. This facility is capable of processing 900 to 1,600 pounds of solid waste per hour, and is said to be capable of volume reduction ratios of greater than 100:1.

SEG is currently seeking approval from EPA for a Part B permit to allow the company to incinerate certain types of mixed wastes in addition to non-mixed LLRW.

Filtration. Filtration is the process of removing solid particles from LLRW fluids by forcing the fluids through a permeable material using gravity, pressure, or vacuum. The solids suspended in the fluids may be lodged within the pores of the filter (called filter-medium filtration), or may build up on the surface as a filter "cake" (called cake filtration). Filters are designed to remove 90% or more of the weight of the suspended solids.

Filtration is used by the nuclear power industry, among other generator types, to remove solids from process water. It is also used to remove radioactive materials from gas emissions.

Ion Exchange. Ion exchange is a process used to separate dissolved solids from liquids by using chemical resins to transfer (i.e., exchange) the atoms in the radioactive material with the atoms attached to the resin material. This waste separation technique, which is employed in nuclear powered plants and others, can reduce the level of radionuclides in liquid waste by factors of 10 to 100.

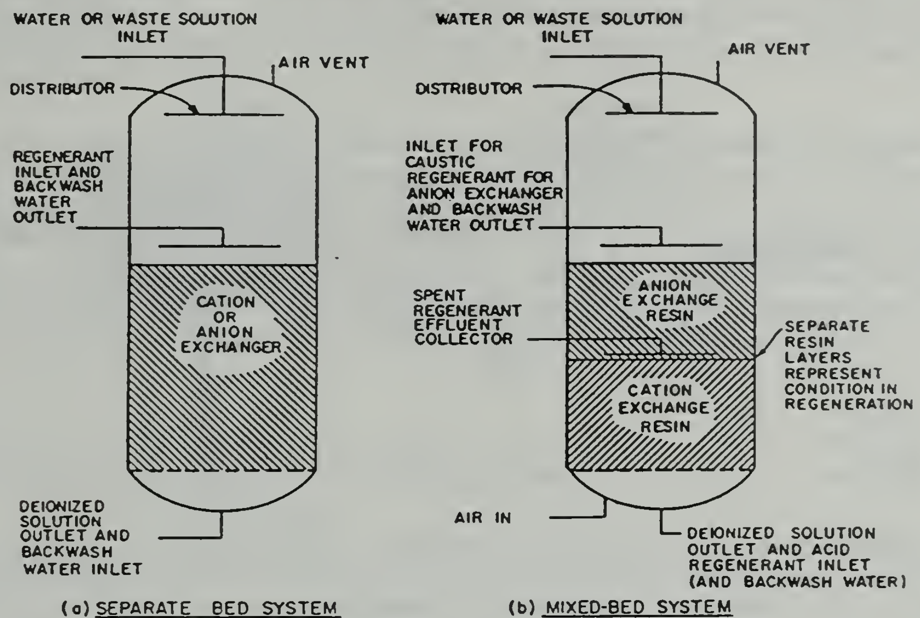
Two typical ion exchange systems are shown in Figure 10-C.

Evaporation. Evaporation is a frequently used volume-reduction technique that removes water from radioactive material by using heat to evaporate, and thereby remove, relatively pure water. The original waste stream becomes more concentrated in waste constituents, and smaller in volume, while the vaporized water can be reused or discharged.

Crystallization. Crystallization is an evaporation-related volume-reduction method in which solids are precipitated out of liquid LLRW. The loss of water results in a more concentrated slurry of radioactive material than conventional evaporation, and thereby reduces the volume of radioactive liquid waste requiring disposal. As with evaporators, the vaporized water can be condensed and discharged or reused in the company's or institution's process.

Figure 10-D illustrates a simplified evaporation/crystallization process.

Figure 10-C
Diagram of Mixed Bed and Separate-bed Ion Exchange Systems



Source: National Low-Level Radioactive Waste Management Program. Low-Level Radioactive Waste Treatment Technology. DOE/LLW-13Tc, Idaho Falls, ID, July, 1984.

Flocculation. The process that gathers small particles of waste suspended in liquid waste into larger particles or clusters is called flocculation. This process is aided by the addition of certain chemicals to the liquid waste, and removes the radioactivity of the small particles.

Precipitation. Precipitation removes dissolved solids from a liquid, transforming them into a solid waste form.

Sedimentation. Gravity, not chemicals, provides the vehicle to remove suspended particles from liquid through the process of sedimentation. Sedimentation, flocculation, and precipitation are often used together to produce a smaller volume of wet solids, which can be separated from any bulk liquid.

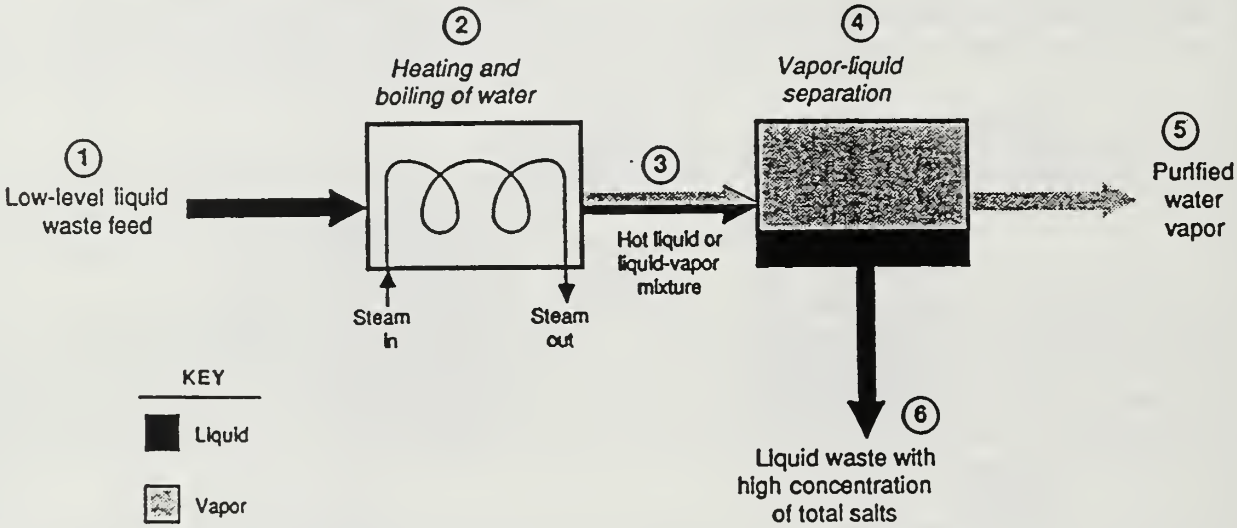
Centrifugation. Centrifugation removes suspended solids using rotating equipment that depends upon centrifugal force to separate solids from liquids. It is used in some nuclear power plants to dewater resins and filter sludges, and can process sludges containing up to 5% solids into sludges with up to 50% solids.

Drying. Various types of drying processes utilize heat to remove liquid and form a dry solid. Dryers include the "fluidized-bed," "in-drum," and "spray" types.

Dewatering. Dewatering technology uses pumps or gravity to draw water from wet solids through filter devices.

Decontamination. Decontamination techniques remove radioactive contaminants from the surface

Figure 10-D
Simplified Evaporation/Crystallization Process



(1) The low-level waste "feed" consists of water contaminated with low concentrations of dissolved radioactive material.
(2) The feed is heated with steam in a heat exchanger, boiling off some water.
(3) A mixture of hot liquid and evaporated water vapor is produced.
(4) The water vapor and liquid are separated into two streams:
(5) One is relatively pure water vapor.
(6) The second is a liquid solution highly concentrated with nonvolatile radioactive material.

Source: National Low-Level Radioactive Waste Management Program. Low-Level Radioactive Waste Volume Reduction and Stabilization Technologies Resource Manual. DOE/LLW-76T. Ebasco Services Inc., Bellevue, Washington, December, 1988.

or near-surface of objects, such as walls, floors, tools, and equipment, or from fluids. The decontamination process is achieved by the transfer of contamination to any of a number of decontamination solutions. These include alkaline permanganate, detergents, mineral acids, organic acids, chelating compounds, and water or steam under high pressure. In addition, sandblasting and electropolishing[19] have also been used with success.

A laundry near Springfield uses decontamination to remove the radioactive contaminants from clothing used at nuclear power plants and in research laboratories.[20] The clothing can be returned to the company or institution for re-use, and the radioactive contaminants in the wash water are treated by decay prior to disposal.

Return to the manufacturer. This volume reduction method is not a "technology," but a "practice."

[19] Electropolishing is an electrochemical process which produces a smooth, polished surface on various metals, which facilitates removal of residual contamination through the use of an electrolytic conductor.

[20] Interstate Nuclear Services launders clothing for radioactive materials users throughout New England.

However, it is included in this list because many companies and institutions in the Commonwealth use this volume-minimizing procedure. Approximately 130 licensees use radioactive sealed sources in connection with therapeutic radiation or instrument calibration. When the radiation inside decays to the point that the sealed sources are no longer useful, they retain levels of radioactivity that require them to be handled as radioactive waste. Sealed sources should be returned to the manufacturer where they may be held for decay, processed for reuse, or disposed of. Each year, numerous Massachusetts licensees return sealed sources to their suppliers.

Recycling: This volume-reduction practice is widely utilized, to enable the repeated reuse of decontaminated or slightly contaminated materials and waste. Tools and equipment, process waters, and some radioactive sources themselves can be recycled for repeated use.

Recycling involves many of the volume-reduction technologies and practices mentioned in this chapter. These include segregation, filtration, ion exchange, evaporation, crystallization, flocculation, precipitation, sedimentation, dewatering, decontamination, and return to the manufacturer.

10.6 Stabilization Treatment Technologies

Before the NRC established disposal standards in 1981, LLRW was packaged in a variety of containers, including cardboard boxes, that were not expected to last or keep the waste intact for hundreds or thousands of years. These containers frequently did not possess short-term structural stability under burial conditions. In addition, there were no standards for the form required for waste in disposal sites. Consequently, waste migration occurred at some of the old disposal sites, because neither the waste form nor the disposal packages were structurally able to withstand burial conditions. (See discussion of former disposal sites and their problems in Appendix 1A of this volume.)

The requirement to ensure "stability" for LLRW, its disposal containers, and the disposal site, is an outgrowth of the lessons learned from the poor waste disposal techniques of the past. Because one way to accomplish the stability required by the NRC is through treatment processes that stabilize the waste, this subject is presented in this chapter along with other treatment techniques.[21]

NRC's regulations governing the disposal of LLRW, 10 CFR Part 61, which characterize stability as a safety objective and a "cornerstone" of the waste disposal system [61.7(b)(1)], require that LLRW placed into a disposal facility must have structural stability. Stability has several objectives:

- It is intended to ensure that the waste does "not structurally degrade and affect overall stability of the site through slumping, collapse, or other failure of the disposal unit and thereby lead to water infiltration;" [10 CFR 61.56(b)]

- It ensures that waste will maintain its physical dimensions and its form under disposal conditions such as the presence of moisture and microbial activity, and activities internal to the waste package, such as radiation effects and chemical changes; and

[21] NRC regulations provide four general ways of achieving stability: (1) the waste may be a stable form; (2) the waste may be processed into a stable form; (3) the waste may be placed into "high-integrity containers" that provide necessary stability over a minimum of 300 years; or (4) build structures at the disposal site to provide stability. Only (2) above is discussed in this chapter.

- it helps to limit exposure to anyone who inadvertently intrudes onto the disposal site after all institutional controls have ended, at a minimum of 100 years after operations cease.

Many of the treatment technologies already described provide waste stability. For example, incineration reduces numerous waste forms into radioactive ash, which is more effectively stabilized than the original wastes. Other common techniques used by waste generators and waste processors to provide stability include solidification and polymerization. These techniques are described below.

Solidification. Solidification is the process of mixing materials with LLRW as it is placed in disposal containers so that it becomes a solid block. The most common material used to bind the waste Into the solid structure Is cement. Other materials used Include asphalt and "plastic" polymers such as vinylesterstyrene.

The NRC requires that stabilized waste meet certaln standards with regard to waste-solidification agent compatibility, long-term resistance to radionuclide leaching, strength and impact resistance, radiation stability, and thermal properties.

Cement solidifies liquid radioactive waste by reacting chemically to the waste and physically encapsulating it. As the cement dries, water In the cement mixture becomes chemically bound Into the solid material.

Cement Is advantageous as a solidification agent because it Is easy to mix, is compatible with most types of waste, has good structural strength, provides good shielding against radioactivity, has low leachability for some radionuclides, is readily available, is low-cost, and has a long history of performance. Its disadvantages are that it increases the volume of waste, it is heavy, and it can cause maintenance problems in controlling the cement powder dust. In addition, cement is an alkaline material and is therefore sensitive to the acidity (pH) of the final LLRW mixture, potentially requiring pretreatment of the waste. Also, it can generate excessive heat while setting up, and it cracks.

Asphalt Is often used for LLRW solidification, especially In Europe and Japan. There is no chemlcal reaction In the use of asphalt with LLRW. Instead, the asphalt surrounds the waste and isolates it from contact with water. The advantages of using asphalt for solidification are that it is capable of solidifying most waste streams, it resists the leaching of certain wastes, it Is relatively Inexpensive, and it develops no free-standing water. In addition, it can volume-reduce aqueous wastes because the asphalt-waste mixing process results in the evaporation of water contained in such wastes. The disadvantages of using asphalt include the need to use heat to melt the asphalt to a conslstency capable of mixing with LLRW, which can cause fires from certaln chemicals vaporizing from the heat. Another disadvantage is that it, too, Is flammable at relatively low temperatures. Also, certain LLRW may swell and crack the asphalt, the asphalt can decompose to gaseous products, and exposure to heat can cause the LLRW-asphalt mixture to separate or liquify. Asphalt also has a low structural strength; it cannot be used to solidify certain organic materials, and it gives off a gas during solidification.

Polymerization. Polymerization is a chemical process used to solidify liquid and wet solid waste by encapsulating small particles or droplets of waste in an Irreversibly hardened polymer matrix. Because polymerlc systems do not require water to solidify, they can result In some volume reductlon. Advantages are that polymer-solidified wastes can meet all NRC technical stability standards, have good resistance to leaching wastes from the hardened material, have good radiation stabllity, and possess compressive strengths of 1,500 to 9,000 pounds per square Inch.

Dlsadvantages Include hlgher cost than other stabllization technlques, and the necessity to measure, handle and mix the chemlcal ingredients precisely. In addition, some wastes may interact chemically and prevent or affect polymerization.

10.7 Exempt Wastes and Processes That Affect S/WVM/E Policies

Regulatory requirements pertaining to source minimization, volume minimization, source and volume elimination and storage for decay have been mentioned in the preceding sections of this chapter. Other proposed or final federal regulations that may have significant impacts on source and waste volume minimization are discussed below.

Existing Regulations

Case-by-Case Exemption. A limited exemption to allow the on-site burial of low-radioactivity waste can be granted an individual licensee, on a case-by-case basis, "to dispose of licensed material in a manner not otherwise authorized in the regulations" under the provisions of 10 CFR 20.2002 of the NRC regulations. The rule requires a licensee to submit an application describing:

- the licensed material sought for the exemption, including quantity and kinds of material, and levels of radioactivity;
- the proposed manner and conditions of disposal;
- an analysis of the nature of the environment, including topographical, geological, meteorological, and hydrological characteristics; and use of ground and surface waters in the general area;
- the nature and location of other potentially affected facilities; and
- procedures to minimize the risk of unexpected or hazardous exposures.

Approximately 40 exemptions (one in Massachusetts) have been granted nationally since this rule became effective. After the NRC promulgated its LLRW disposal regulations in 1983, it began discouraging radioactive materials licensees from using on-site burial. The one licensee authorized to bury on site in Massachusetts discontinued this activity in the mid-1980s.

Disposal to Sewer Systems. NRC regulations prohibit the discharge of licensed material into sanitary sewer systems except for very small quantities that are assumed to be diluted by the volume of sewage flowing through the system. The rule prohibits any licensee from using the sewer system to dispose of more than a combined total of one curie per year of all radioactive materials, with the exception of Carbon-14 and Hydrogen-3. Up to one curie per year of Carbon-14, and as much as five curies per year of Hydrogen-3 may be released into the sanitary sewer system. [10 CFR 20.2003]

This regulation permits hospitals to use the sewer systems for disposal of radioactively contaminated human wastes from individuals undergoing medical diagnosis or treatment with radioactive materials. No limits are set on the quantity of such wastes allowed for disposal in this way.

Exempt Quantities. Minute quantities of certain radionuclides do not have to be disposed of in licensed LLRW disposal facilities under 10 CFR 20.2005 of the NRC regulations. This rule allows:

- 0.05 microcuries or less of Hydrogen-3 or Carbon-14 in liquid scintillation fluids (see Chapter 4, description of types of medical wastes); and
- 0.05 microcuries or less of the same two radionuclides per gram of animal tissue "averaged over the weight of the entire animal" to be disposed of as non-radioactive trash.

Release in Effluents to Air or Water. In addition, NRC allows radionuclides in radioactive materials or LLRW to be released in effluents (air or water) as long as the release remains within the radiation dose limits allowed by NRC regulations, and described earlier in this chapter for occupational and public doses. Appendix B to 10 CFR 20.1001 through 20.2401 includes tables showing allowable "annual limits on intake" (ALIs) and derived air concentrations (DACs), and the chemical form of each radionuclide. The concentration values given in Table 2 of Appendix B (effluents: air or water) are equivalent to the radionuclide concentrations which, if inhaled or ingested continuously over the course of a year, would produce a total effective dose equivalent of 50 millirem.

Withdrawn Regulatory Proposals

Below Regulatory Concern. The 1985 LLRWPAA contains a directive from Congress that the NRC develop standards and procedures for exempting from regulatory requirements certain types and quantities of radioactive material. Such an exemption would have allowed certain wastes with low quantities of radioactive contamination to be disposed of as solid waste.

In August, 1986, the NRC released its first policy statement and implementation plan which set general guidelines for managing waste that the NRC proposed should be declared "below regulatory concern" (BRC). A second policy statement was issued by the agency four years later, in June, 1990.

The 1990 statement established an individual dose criterion of one millirem per year per exemption, and a collective dose criteria of 1,000 person-rems per year per exemption. NRC also proposed to raise the exemption level to 10 millirem per year exposure for the individual dose.

Between the publication of the two policy statements, opposition developed among those who opposed the use of local solid waste landfills for the disposal of BRC materials, and among numerous state officials who felt the assignment of LLRW management and disposal responsibility to the states precluded NRC's adjustment of the definition of LLRW.

Some LLRW generators opposed the policy as well, including the nuclear-powered utility industry, which initially sought a BRC exemption that was projected to eliminate from regulation about 30% of their LLRW.[22] According to one nuclear power group -- the U.S. Council on Energy Awareness -- the NRC's 1990 policy statement went far beyond the dose level sought by the utilities (one millirem exposure per exemption), and ignored the utility's recommendation that no BRC material be recycled.[23] Both nuclear-powered utility companies in Massachusetts (Boston Edison and Yankee Atomic Electric Company) publicly stated their opposition to using local landfills for the disposal of BRC waste.

Several states that opposed the BRC policy statement enacted legislation banning the unregulated disposal of BRC waste. They include Nevada, Pennsylvania, Vermont, Minnesota, and Illinois.

Provision in Massachusetts Law

The Massachusetts LLRW Management Board communicated its opposition to the Congressionally

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[22] Robinson, P., and Vance and Associates. Technical and Economic Evaluation of Controlled Disposal Options for Very Low Level Radioactive Wastes. EPRI NP-6947-D. Electric Power Research Institute, August, 1990.

[23] Scott Peters of the U.S. Council on Energy Awareness as reported by Patrick Quinn. "Below Regulatory Concern," Hazmat World, October, 1990.

mandated NRC policy on the basis that the policy would unnecessarily complicate the Board's activities at a time when meeting the mandates of federal law was a difficult and time-consuming task. In testimony to the NRC, the Board also argued that the proposed BRC standard was contrary to Massachusetts law.

Unlike other states that were forced to pass anti-BRC legislation hastily, Massachusetts law already contained an anti-BRC provision. Chapter 111H explicitly prohibits the disposal of LLRW in any landfill. The law gives the Management Board the authority to manage materials and practices of all waste currently regulated as LLRW, including waste that may be declared BRC in the future. These provisions of Chapter 111H are founded on the principles of managing LLRW on the basis of the state's economic concerns (such as matters of facility utilization and allocation), and on the basis of guarding against the potential liability of the Commonwealth for personal injury and property damage.

Late in 1990, the NRC issued a third BRC-related policy statement withdrawing its earlier proposal and recognizing the states' rights to manage BRC waste. Using wording very similar to the testimony submitted by Massachusetts, it included the following statement:

> "NRC regulations exempting BRC wastes will not affect the authority of State or local agencies to regulate BRC wastes for purposes other than radiation protection in accordance with Section 274b of the Atomic Energy Act."

Then, in February, 1991, the NRC proposed a "consensus" process to bring together organizations representing diverse BRC opinion, and to attempt to reach a compromise. Because NRC ground-rules required all groups to cease their Congressional lobbying efforts for passage of a national anti-BRC law, environmental organizations refused to participate. The BRC proposal, therefore was shelved by the NRC.

In October, 1992, the Comprehensive National Energy Policy Act was signed into law. Among the law's 30 titles and 3,010 sections is a provision authorizing states "to regulate, on the basis of radiological hazard, the disposal or off-site incineration of low-level radioactive waste" if the NRC exempts such waste from regulation after the date of the energy law's enactment. The energy law also revokes the August, 1986, and July, 1990, BRC policy statements previously published by the NRC.

In an August, 1993, Federal Register notice, the NRC formally withdrew its 1990 and 1986 BRC policy statements. While the 1992 Energy Policy Act had revoked those statements, it did not revoke NRC's authority under the Atomic Energy Act to exempt classes of radioactive material from licensing. The NRC has indicated that it will continue to consider individual exemption requests using criteria and guidance in existence prior to the 1990 policy statement. It will also continue its work leading to rulemaking on radiological criteria for site cleanup and decommissioning, a related subject that was contained in the original BRC policy statement.

The EPA, also charged with setting standards on radiation exposure, has proposed a four millirem per year individual exposure limit, allowing materials and waste below that level to be exempt from its regulations. It is not clear what action, if any, the EPA will take to adopt its BRC proposal, in light of the Congressional position on BRC in the 1992 Energy Policy Act.

10.8 Recommendations for a Massachusetts Source and Waste Volume Minimization and Elimination Program

Chapter 111H requires LLRW generators to take certain actions pertaining to source and volume minimization and elimination, and storage for decay. These activities are required elements of DPH

regulations [Chapter 111H, section 13], compelling LLRW generators to:

- avoid unnecessary contamination of items during the use of radioactive materials;
- segregate radioactive waste from non-radioactive trash; and
- prepare and implement plans for the utilization of all appropriate methods for source minimization, volume minimization, and storage for decay.

As noted the minimization program described in Chapter 111H, section 13, assigns regulatory responsibility to DPH. This portion of the law was written with the assumption that DPH would become the regulatory agency of state government implementing Agreement State authority to control the licensing requirements for either or both (1) radioactive materials users and (2) centralized storage, treatment, or disposal facilities sited within the Commonwealth according to the requirements of Chapter 111H. The Commonwealth officially requested approval from the NRC to assume regulatory authority over both licensing areas, with an application submitted to the NRC by Governor William F. Weld in July, 1992. The NRC generally takes two years or longer to review and approve an Agreement State request.[24]

As has been noted in other chapters of this Management Plan, several of the provisions of Chapter 111H regarding DPH responsibilities cannot be implemented by that agency if Massachusetts does not become an Agreement State. In recommendations contained in Chapter 2, the Management Board endorses the concept of Agreement State status as a means to improve both the level of regulatory control over the use of radioactive materials and the production of LLRW, and as a mechanism to enable licensees to reduce their licensing expenses.

Until Agreement State authority is granted by the NRC, the Management Board will use its annual survey of radioactive materials users to pose questions about source elimination/minimization and LLRW volume minimization activities, and to press for voluntary participation by the user community.

Assuming success in achieving Agreement State status, the Management Board recommends the following for a DPH program of S/WVM/E:

S/WVM/E Program. A source and volume minimization/elimination program is necessary to accomplish these activities. The type of program recommended by the Management Board is consistent with the intent of the legislators, citizens, environmentalists, radioactive materials licensees, and others who participated in writing Chapter 111H.

The drafters of the law wanted to ensure that every radioactive materials user takes responsibility for achieving source and volume minimization and elimination, but did not envision a heavily bureaucratic or regulatory program. Instead, they wanted to use the law to educate licensees about technically sound and economically feasible elimination and minimization procedures, knowing that beneficial uses of radioactive materials -- such as medical diagnosis and treatment -- need to continue.

The Management Board recommends the same type of program. It does not propose a regulatory program containing percent reduction goals, but instead suggests a program that is heavily dependent upon building a cooperative relationship with licensees for the purposes of:

(1) promoting and coordinating exchanges of information among LLRW generators on the technical aspects of minimization processes and procedures;

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[24] See the detailed discussion on the Agreement State program in Chapter 2

(2) providing an educational outreach program element to assist the public, media, policy-makers, and others to evaluate source and waste elimination and minimization, and other radioactive waste issues from a position of knowledge; and

(3) encouraging policy development, planning, and implementation of source and waste elimination and minimization strategies.

Emphasis on eliminating or minimizing radioactive sources. The Management Board recommends that the DPH emphasize source minimization and elimination over activities involving LLRW volume minimization. The Board recommends that the DPH program involve radioactive materials users, persons with professional training and experience in environmental protection, and others qualified to provide advice on the development of the minimization program and to evaluate its implementation and effectiveness.

Coordination with TURA. In addition, the Board recommends that DPH coordinate its technical assistance efforts with the State's Toxic Use Reduction Act (TURA) Office of Technical Assistance, a group of technical experts who are implementing TURA's mandate to help hazardous waste generators identify and achieve new methods and technical processes for reducing toxic chemical waste in the workplace.

The TURA law requires companies that use toxic chemicals (that produce "hazardous" waste) to develop plans to reduce or eliminate processes using such chemicals. This law does not set performance standards or discharge limits for the use of hazardous chemicals, but instead requires individual companies to set their own goals. However, TURA does give three state government entities[25] authority to monitor groups of toxic chemical users, categorized by similar chemical uses, and to make recommendations to an Advisory Council that can develop "Priority User Segments" in order to allow the targeting of minimization efforts on specific chemicals or certain operations.

The Management Board supports the TURA philosophy, whereby radioactive materials users would set their own goals, and DPH would evaluate the accomplishments of categories of similar companies and institutions. The Board believes that the use of the Priority User Segments concept will aid DPH in evaluating similar segments of radioactive materials use, to ensure that one licensee's accomplishments to eliminate sources and/or minimize sources and LLRW volumes can be translated to other licenses in an analogous category of use.

Advisory Council to evaluate minimization program. The Board also recommends that DPH establish an Advisory Council similar to that used under the TURA program, to assist in evaluating minimization plans and their effectiveness. The Board suggests that program advisors from the radioactive materials industry and other groups work with the Governor's Advisory Council on Radiation Protection, who could be charged with similar TURA Advisory Council duties.

Generator's history of minimization practices important. In addition, the Board urges that when comparisons are made of "alike" licensee activities, each user's history of source and volume elimination/minimization should be evaluated.

Use short-lived nuclides, where feasible. The Board recommends that short-lived radionuclides should be substituted for long-lived nuclides wherever practical.

Statement against BRC. In addition, the Board recommends that the DPH program regulations

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[25] The three agencies are the Office of Technical Assistance within the Executive Office of Environmental Affairs, the Department of Environmental Protection (DEP), and the Toxic Use Reduction Institute (TURI) headquartered at the University of Massachusetts, Lowell.

include language supporting the Chapter 111H policy against "below regulatory concern" (BRC).

Require minimization plan by generators. The Management Board also recommends that the regulatory aspects of a program of S/WVM/E and storage for decay -- i.e., the DPH regulations necessary to implement the program -- should focus on the requirement within Chapter 111H that every LLRW generator "prepare and implement plans for the utilization of all appropriate source minimization, volume minimization, and storage for decay methods." [Chapter 111H, section 13]

The Board recommends that each minimization plan include:

- a "policy statement" presenting the licensee's goals for eliminating radioactive sources where practical (giving attention to the total hazard of alternative chemicals), and achieving minimization;

- a "summary report" explaining the licensee's evaluation of possible opportunities to achieve additional levels of source elimination and or source and LLRW volume minimization;

- a "minimization plan" describing the licensee's intended actions to achieve the minimization goals with the objective of producing zero LLRW in the future;

- a "summary of employee training" activities to ensure that all employees have basic knowledge of common waste problems, and all necessary workers have the needed technical skills to perform elimination and minimization activities;

- an "evaluation" of how source elimination/minimization, volume minimization, and storage for decay can be incorporated into any future business plans; and

- a descriptions of the strategies to be used to measure the success of the licensee's minimization program.

Make reporting forms available; schedule for submission. The Management Board suggests that the DPH develop forms to enable LLRW generators to quickly and succinctly prepare the "summary report" and "evaluation" elements recommended above. The Board does not believe that minimization plans are necessary to be submitted each year, especially since some procedures to implement minimization activities could involve longer start-up periods. The Board suggests that minimization plans be required once every five years, and be updated yearly, if necessary, as part of the annual survey of radioactive materials users required by section 7 of Chapter 111H.

Details of the Board's recommendations for source elimination/minimization, volume minimization, and storage for decay can be found in Appendix 10A.

Conduct follow-up assessment. The economic and environmental benefits of source and volume minimization and elimination and storage for decay can be substantial, even though they may represent a small investment. The overall benefit to the radioactive materials user and to the general public can be determined by conducting a follow-up operational assessment, and comparing the results to the baseline information collected from an initial assessment, including the impact on products and services.

The ideal objectives for the user of radioactive materials, in addition to the program objectives stated above, would be the reduction of both the gross volume and the radioactivity per unit volume, while net profit is maintained or increased.

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Appendix 10A: Management Board Recommendations to DPH Concerning Source and Volume Elimination/Minimization, and Storage for Decay

Massachusetts General Laws c. 111H (Chapter 111H) mandates the establishment of a program of radioactive materials source and low-level radioactive waste (LLRW) volume minimization and storage for decay.

Procedural steps in Chapter 111H pertaining to minimization provide that:

(1) as part of the Management Plan development, the Low-Level Radioactive Waste Management Board shall include "a review and analysis of the effectiveness and feasibility of, and the development of recommendations for, encouraging or requiring minimization of the volume, radioactivity, toxicity, or other characteristics of low-level radioactive waste" [section 12(b)(9)], and

(2) the Department of Public (DPH), "after consultation with the Board, shall establish a program for low-level radioactive waste source minimization, volume minimization and storage for decay by generators." [section 13]

To assist it in developing recommendations for a minimization program, in 1990 the Management Board requested, and received, technical assistance from the U.S. Department of Energy (DOE). The DOE assistance resulted in the preparation of two "guidance" documents. One provides direction to state officials on the elements that should be included in a minimization program, and the other offers guidance to LLRW generators to develop their minimization plans. Both documents are available from the Management Board office, 100 Cambridge Street, Boston, MA 02202 (telephone [617] 727-6018).

Detailed Management Board recommendations are specified below for a DPH program to eliminate or reduce radioactive sources, and minimize LLRW volumes. These recommendations are elaborated in Section 10.8 of Chapter 10 of this Management Plan volume, and should be reviewed jointly.

1. Goals and Objectives

The principal goals of the Commonwealth's radioactive source minimization/elimination and LLRW volume minimization, and storage for decay program should be to eliminate, where possible, or reduce the use of radioactive materials, minimize the volume of LLRW, and encourage storage for decay of short-lived radionuclides to the maximum extent feasible. The objective of this program should be to reduce the radioactive and chemical hazards associated with these materials, which, if misused or allowed to enter the air, land, or water, could harm the public and damage the environment.

2. The minimization program should be comprised of three basic elements: (1) information exchange and technical assistance, (2) educational outreach, and (3) regulatory actions.

The Management Board offers to provide assistance to DPH in its implementation of the first two

program elements. The implementation of the third element would be the sole responsibility of DPH.

3. **DPH should involve radioactive materials users, persons with professional training and experience in environmental protection, and others qualified to provide advice (especially the Governor's Advisory Council on Radiation Protection) on the development of the minimization program and to evaluate its implementation and effectiveness.**

Such an advisory group could serve as a "sounding board" to comment on specific proposals aimed at achieving the program elements (described below).

4. **DPH should evaluate each radioactive materials user's minimization program during licensing reviews.**

The Management Board recommends that DPH consult with the Board, the Governor's Advisory Council on Radiation Protection, and other advisors on the development of criteria for compliance with the minimization regulations.

The Management Board's specific recommendations on the three basic program elements are described below.

Program Element #1: Information Exchange and Technical Assistance[1]

The goal of the information exchange and technical assistance minimization program element should be to ensure that all potential radioactive sources and LLRW can be considered for elimination, minimization, and storage for decay, and technical information on process changes can be made available to radioactive materials users.

Groups of radioactive materials users and LLRW generators should assist in analyzing production processes that generate waste and identifying possible elimination and minimization techniques. Some of the groups which could assist in these activities include:

Users of specific radionuclides. Specific radionuclides that are common to several radioactive materials users' waste streams, or user processes that produce similar wastes, provide an opportunity to focus on mutual waste minimization problems. Grouping users into (a) commercial operations that utilize radioactive materials, (b) health care institutions, (c) educational and research institutions, (d) nuclear-powered utilities, or (e) other "alike" user activities, will facilitate the sharing of ideas and suggestions that can help meet the objectives of the Commonwealth's source elimination/minimization and LLRW volume minimization program.

Large-volume generators. Often, the more waste produced, the greater the opportunity to institute elimination, where practical, and minimization strategies. Most large-volume generators in Massachusetts have waste minimization programs in place and could provide valuable insights to other radioactive materials users.

Related Industries. Related industries are those that use radioactive materials in a peripheral way

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[1] Much of the description of these program elements is taken directly from the DOE technical assistance guidance report prepared for the Management Board, and entitled, Commercial Radioactive Waste Minimization Program Development Guidance by D.K. Fischer, DOE/LLW-104, EG&G Idaho, Inc., Idaho Falls, ID, January, 1990.

and whose principal services or products are only indirectly related to the use of radioisotopes. Environmental engineering firms that use gauges made of radioactive sources sealed in metal for various field-testing activities are an example of a "related industry." These companies may not feel the need to participate in a waste minimization program, even if they use modest amounts of radionuclides as sealed sources or tracers. However, knowledge gained by sharing information and recognizing potential health, safety, and economic advantages could provide the impetus to practice source and waste elimination and minimization. The Commonwealth, in turn, could determine the level of involvement necessary to provide technical assistance by the data generated from "related" industries.

In addition, an exchange of information and technical assistance to individual radioactive materials users could be provided by knowledgeable state agency staff. Upon the request of a radioactive materials user, a technical staff person could visit the user's facility to help identify and evaluate specific minimization opportunities. This assistance may be offered as a "helping hand" and not as a mandate for change.

Program Element #2: Educational Outreach

The goal of the educational outreach program element should be to provide factual, unbiased information to the general public, the news media, legislators, policymakers, and staff regulators. In addition, it should serve as a resource for in-house employee training programs developed by radioactive materials users.

The purpose of educational outreach should be to assist the public and others to evaluate source elimination, where possible, and minimization, as well as LLRW minimization and other radioactive waste issues from a position of knowledge. Media coverage, public service announcements, contact with concerned citizens' groups, newsletters, and bulletin boards should be used to encourage the intended audience to take advantage of available educational services.

Examples of the types of educational outreach services include:

Resource center on source and volume elimination/minimization. A resource area could be designated in the offices of the Management Board or DPH so that citizens and radioactive materials users could have access to materials on the subject of minimization. The resource area could provide:

(a) introductory information regarding overall waste management concepts and policy, technical issues, benefits, constraints, etc., affecting radioactive waste management;

(b) technical information on specific source elimination or minimization and LLRW volume minimization technologies and techniques, journal articles, qualified consultant lists, etc.;

(c) interaction with national information exchange services; and

(d) cost/benefit case histories, including financing options.

Open forums. Open forums bring the public, radioactive materials users, and regulators together in an informal atmosphere to share information and voice concerns. The forums could be scheduled at various locations statewide at times convenient to the materials users and the public. They could also be given in schools as part of an environmental/public health studies program. The agendas may include topics pre-selected by the public, information about local radioactive materials users' activities, general LLRW management, specific source and waste elimination and minimization programs developed by the user community, benefits and detriments of products and services using radionuclides, etc.

Facility tours. Tours held at the invitation of radioactive materials users would offer the public a visual experience that enhances their understanding of radioactive materials use and LLRW generation and management. The ability to relate to specific source elimination/minimization and LLRW minimization efforts in the workplace fosters a positive attitude and recognition for the radioactive material user hosting the tour. The arrangement of such tours should be coordinated as part of open forum meetings.

Fact sheets. These are short, one- or two-page discussions of successful elimination and minimization techniques. The fact sheets could be available to news media science editors, and distributed at open forum meetings, facility tours, and other LLRW-related meetings open to the public. They could also be available in public libraries and on request.

Newsletter. A newsletter published routinely could communicate radioactive source and waste volume minimization and elimination technologies, and highlight the latest techniques found to be successful. The newsletter could also serve as a means to bring together radioactive materials users with similar LLRW streams, that could benefit from sharing minimization experiences with other waste generators. The mailing list could include schools with science or environmental curricula, concerned citizens and groups, the media, regulators, legislators, policymakers, and radioactive materials users.

Educational outreach through volunteers. Educational outreach also can be provided through a group of community volunteers whose professional training and experience are in the fields of environmental protection, academic organizations, professional societies, citizen groups, and radioactive materials users. Such organizations as the League of Women Voters, Chambers of Commerce, and other local civic groups often have the resources to conduct or sponsor seminars, perform studies, provide handouts, and promote public awareness. Retired professionals could be recruited to supplement paid personnel.

Program Element #3: Regulatory Actions

The goal of the regulatory actions program element should be to ensure that source elimination, where appropriate, source and LLRW volume minimization, and storage for decay are integral parts of every LLRW generator's management program.

In order to meet this goal, the Management Board recommends that DPH include the following points in its source elimination/minimization, volume minimization, and storage for decay regulations:

1. Every generator should prepare and submit to the Commonwealth a **minimization plan** that identifies objectives to achieve source elimination, where feasible; source minimization, volume minimization, and storage for decay. These objectives should include activities required in section 13 of Chapter 111H:

   - LLRW generators must avoid unnecessarily contaminating items while using radioactive materials, and

   - LLRW generators must segregate radioactive waste from non-radioactive trash.

2. The minimization plan should include:

   (a) A **minimization policy statement** that presents the licensee's goals for achieving minimization, through the elimination of radioactive sources, where possible, and the minimization of sources and LLRW volumes, and that assigns responsibility to an individual or group to accomplish the objectives. The policy should be signed by the company or institution's chief executive officer or designee.

The importance of this message should not be underestimated; it will give notice to all employees that the company or institution **will** practice minimization as a standard operating procedure.

(b) A **summary report** (forms to be provided by DPH) that explains the **operational assessment** conducted by the licensee to review processes, technologies, procedures, and cost requirements systematically. Its purpose is to identify source and volume elimination and minimization and storage for decay opportunities by performing an options assessment, a technical analysis, and an economic analysis. Assessment data collected and compiled to prepare the report should, at a minimum, answer the following questions:

(1) What LLRW streams are generated and what are the characteristics of the constituent components of the LLRW?

(2) How much LLRW is generated (noncompacted volume) over a prescribed period of time (e.g., one year)?

(3) How much radioactivity (curies per unit volume) is present in the volume of LLRW identified, what are the principal and subordinate radionuclides, and what assessment and actions have occurred to reduce or eliminate radioactive sources by substituting non-radioactive materials?

(4) Are there any hazardous constituents or hazardous characteristics in the LLRW that would qualify it as mixed waste?

(5) What processes or operations contribute to the use of radioactive materials and the generation of LLRW?

(6) What housekeeping practices are currently used that may cause or minimize waste generation?

(7) What process controls are currently in place to reduce or avoid using radioactive sources and to reduce or avoid LLRW production?

(8) What technique and technology options are suitable for source and LLRW volume elimination/minimization; how do they compare to each other and to existing practices; and what benefits or detriments can be expected?

(9) How much, and for how long, will the technique and technology options disrupt the process or service before they become routine?

(10) What are the economic options, and how do they compare with established economic criteria (e.g., payback period, return on investment)?

Activities Involved in Operational Assessments

Operational assessments may be conducted in-house by the generator's staff or by an independent consulting firm. Either way, active participation by management, purchasing, maintenance, production, and engineering should be encouraged. In general, the activities for an assessment should include:

(1) Familiarity with the facility and the process or service that uses radioactive materials and generates LLRW. This may be accomplished by reviewing design, operating,

and maintenance documentation.

(2) Identification and characterization of the LLRW stream(s) which result from the process or service. Process flow diagrams, analytical test data, waste shipment manifests, radioactive materials purchases, and inventory records are potential information sources.

(3) Prioritization of the radioactive sources and LLRW streams to select one or more for minimization. Concerns that should be addressed when making this selection include:

i. Elimination or minimization potential

ii. Reclassification potential

iii. Compliance with current and future regulations

iv. Potential liability

v. Volume and activity of the LLRW

vi. Cost/benefit relationship

(4) Analysis and selection of a technically-feasible source elimination or source and LLRW volume minimization technique or technology. The process or service that uses radioactive materials and generates the LLRW must be analyzed relative to candidate techniques and technologies. If techniques or technologies have already been developed, and minimization is believed to have reached optimum levels, the summary report should indicate what activities will allow such minimization to continue.

(5) Analysis of the direct and indirect capital costs and operating costs associated with the source elimination or minimization, and LLRW volume minimization activity, as compared to on-site storage and increasing disposal costs. These should be considered relative to available funds, payback period, and return on investment.

(6) Evaluation of both tangible and intangible benefits and detriments. Projects are not always accepted on just their technical merits; alternatives or modifications must also be explored.

(7) Evaluation of the progress and success of the source elimination or minimization and LLRW minimization effort. This action should be undertaken periodically after minimization plans are instituted.

(8) Performance of an operational assessment whenever a new product or substantial change in service is being considered.

(c) A **minimization plan** detailing actions to achieve the minimization program. This plan should include:

(1) the scope of work necessary to develop and implement the program;

(2) a best estimate of the schedule for implementing each identified task;

(3) requirements for anticipated personnel, materials and equipment; and

(4) a range of cost estimates of all program elements.

If a minimization program is already in place, the plan should indicate what activities will allow minimization to continue at an optimum level.

(d) A **summary of employee training** activities which ensure that all employees have basic knowledge of common waste problems, and all workers involved directly with the source elimination or minimization, and LLRW volume minimization program have the technical skills necessary.

(e) An **evaluation** (form to be developed by DPH) of how source and volume minimization/elimination can be incorporated into any future business plans.

(f) A description of the **strategies** to be used **to measure** the **success** of the minimization program.

3. The minimization plan should be submitted once every five years and updated yearly, as necessary, as part of the annual survey required by section 7 of Chapter 111H.

4. DPH should review minimization plans and monitor their implementation during inspections incidental to licensing review.

Storage For Decay

Minimization plans that reduce the radioactivity of the waste through storage for decay should include the following considerations:[2]

(1) Identify radioisotopes and waste that can be considered for storage for decay. Develop a written set of procedures outlining handling and processing steps necessary to isolate those wastes.

(2) Identify an area where the storage for decay can occur. Evaluate the size of the area to ensure it is spacious enough to accommodate all wastes to be accumulated through the entire decay cycle.

(3) Identify adjacent unrestricted areas to ensure adequate shielding is available to maintain radiation levels below specified limits.

(4) Establish adequate security measures for the area or areas where storage for decay will take place.

(5) Establish a radiation survey procedure to (i) measure radiation levels in adjacent

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[2] Modified from State of Maryland procedures for nuclear medicine programs. National Low-Level Radioactive Waste Management Program. Improved Low-Level Radioactive Waste Management Practices for Hospitals and Research Institutions. DOE/LLW-21T, EG&G Idaho, Idaho Falls, ID, July, 1983.

unrestricted areas at least weekly, and (ii) measure the presence of contamination in restricted and unrestricted areas.

(6) Develop written procedures to monitor the waste in storage for decay areas to ensure it has decayed to background levels prior to disposal.

(7) Maintain records of all storage for decay and disposal activities, especially radiation surveys.

Chapter 11: Providing Treatment Capacity for LLRW Generated in Massachusetts

11.1 Introduction

Chapter 10 discusses treatment technologies and practices utilized extensively by radioactive materials users to minimize their radioactive sources, reduce their low-level radioactive waste (LLRW) volumes, and eliminate radioactively-contaminated waste through storage for decay. Other treatment practices that stabilize LLRW, but do not necessarily reduce its volume, as well as policies and regulations that impact LLRW volume reduction (i.e., "BRC," exempt quantities, sewer system discharge, emissions in air and water, etc.), are also described in Chapter 10.

This chapter analyzes the treatment technologies and practices described in Chapter 10 according to their potential health, safety, and environmental impacts; their climatic, geologic, and hydrogeologic requirements; their suitability for use in the Commonwealth; and their cost-effectiveness. This chapter also summarizes federal and state regulations pertaining to LLRW treatment, and makes recommendations to improve the safety or efficiency of treatment technologies and practices, if employed by the Commonwealth at a centralized LLRW treatment facility.

The two chapters that follow this one contain similar evaluations of the technologies and practices for LLRW storage and disposal.

11.2 Federal and State Regulations Controlling Treatment On Site and at a Centralized Treatment Facility

As noted in the previous chapter, LLRW "treatment" is defined in the Massachusetts Low-Level Radioactive Waste Management Act, Massachusetts General Laws c.111H (Chapter 111H) as:

> "any method, technique, or process, including source minimization, volume minimization and storage for decay, designed to change the physical, radioactive, chemical or biological characteristics or composition of low-level radioactive waste in order to render such waste safer for management, amenable for recovery, convertible to another usable material or reduced in volume." [Chapter 111H, section 1]

Table 11-1 lists the treatment technologies available for use in Massachusetts, and notes the page numbers in Chapter 10 where a brief explanation of each technology can be found.

LLRW treatment is regulated at the federal level in connection with rules controlling licensing, packaging, transportation, and disposal. Radioactive materials users are able to employ certain treatment techniques and practices on site, under conditions of their U.S. Nuclear Regulatory Commission (NRC) licenses, and in compliance with additional requirements and permits of the U.S. Environmental Protection

Table 11-1 Treatment Technologies and Practices for LLRW			
Technology Description	**Chapter 10 Page No.**	**Technology Description**	**Chapter 10 Page No.**
Case-by-Case Exemptions	10-29	Ion Exchange	10-27
Centrifugation	10-25	Polymerization	10-28
Compaction	10-20	Precipitation	10-2[illegible]
Crystallization	10-24	Recycling	10-27
Decontamination	10-25	Return to Manufacturer	10-26
Dewatering	10-2[illegible]	Sedimentation	10-25
Drying	10-25	Segregation	10-27
Effluents Release	10-30	Sewer System Discharge	10-29
Evaporation	10-24	Shredding	10-22
Exempt Quantities	10-29	Solidifcation	10-28
Filtration	10-24	Stabilization	10-27
Flocculation	10-25	Storage for Decay	10-13
Incineration	10-22	Supercompaction	10-20

Agency (EPA). Certain treatment technologies are required to prepare LLRW for shipment and disposal to conform with regulations of the NRC, EPA, and the U.S. Department of Transportation (DOT).

Shipping requirements pertaining to waste form, radiation levels, package types, and package classification are regulated by the NRC and DOT, and are discussed in detail in Chapter 9 of this volume.

NRC Treatment Regulations

The NRC regulates LLRW treatment at the site where the waste is generated and at centralized disposal facilities, by setting various conditions in each license. For on-site treatment, a radioactive materials user's license may allow an LLRW generator to perform a number of treatment practices prior to packaging waste for storage or disposal. Requirements in the NRC's radiation protection standards, Title 10, Part 20, of the Code of Federal Regulations [10 CFR Part 20], limit radiation exposures for activities involving on-site treatment -- such as compacting various waste forms, or segregating different waste types, etc. -- to the same maximum levels described in Chapter 3 of this volume. On-site treatment must follow the ALARA (as low as reasonably achievable) principle for occupational exposures, as well as exposures to the public. Similarly, 10 CFR Parts 30-35, which regulate the use of byproduct material; Part 40, which regulates the use of source material;[1] Part 50, which regulates nuclear-powered utility plants; and other Parts of the NRC regulations, require on-site treatment activities to fall within the licensing standards of these regulations. NRC regulations prohibit on-site incineration of LLRW except in two instances. [10 CFR 20.2004] It is

[1] "Byproduct material" means any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material. "Source material" is any radioactive material (except special nuclear material) that contains 0.05% or more of uranium, thorium, or any combination of the two.

allowed (1) if a licensee gains specific approval from the NRC pursuant to 20.2002, or (2) if the waste containing certain radionuclides has the following low levels of radioactivity:

- 0.05 microcuries or less of Hydrogen-3 (H-3) or Carbon-14 (C-14) per gram of medium, used for liquid scintillation counting; and

- 0.05 microcuries or less of H-3 or C-14, per gram of animal tissue averaged over the weight of the entire animal. [10 CFR 20.2005]

Treatment is also regulated by the NRC in connection with its waste disposal requirements for centralized disposal facilities. These requirements, which are similar to those set by the states that, before 1992, hosted commercial disposal facilities for the LLRW disposal needs of the entire nation (i.e., South Carolina, Nevada, and Washington), require treatment prior to disposal. They include:

- Liquids must be solidified or packaged with absorption materials capable of absorbing twice the liquid's volume;

- LLRW may not be packaged to contain more than 1% of the volume as free liquid;

- LLRW cannot be capable of exploding, explosive decomposition or reaction, or reacting explosively with water;

- LLRW cannot be flammable;

- LLRW cannot contain or produce toxic gases, vapors, or fumes;

- LLRW in gaseous form cannot have more than 100 curies per container, and cannot exceed 1.5 atmospheres at 20 degrees Centigrade; and

- LLRW containing hazardous, biological, pathogenic, or infectious material must be treated to eliminate or reduce to the maximum extent practicable these potential hazards. [10 CFR 61.56]

EPA Regulations on Treatment

EPA regulations also control both on-site treatment activities, and those at centralized treatment facilities. However, EPA requirements apply only to LLRW that is mixed with materials that are listed as hazardous, or that exhibits the characteristics of hazardous waste, known as "mixed" waste. EPA regulations require mixed waste generators to reduce the volume and toxicity of mixed waste to the extent that is "economically practical."

EPA regulations allow mixed waste in land disposal facilities only if certain facility requirements and land disposal restriction treatment standards are met. These requirements include double liners of impermeable material placed beneath the waste disposal units to prevent contamination of soil or groundwater from waste packages that may leak over time. The three commercial LLRW disposal sites in South Carolina, Nevada, and Washington that accepted most of the commercial LLRW requiring disposal in the nation prior to 1992, do not meet EPA requirements for mixed waste disposal, and are therefore not authorized to accept mixed waste. A fourth LLRW disposal facility, located in Utah (Envirocare of Utah, Inc.) and licensed to accept only LLRW with limited amounts of radioactivity, is permitted by the EPA to accept certain low-radioactivity mixed waste.

The problems of mixed waste storage, treatment, and disposal, due to the sometimes contradictory and often duplicative mixed waste regulations of the NRC and EPA, are discussed in detail in Chapter 8.

State Regulations on Treatment

Several provisions of state law assign authority over radioactive materials and LLRW to the Massachusetts Department of Public Health (DPH). One such law is section 5N of M.G.L. c.111, which authorizes DPH to regulate the radioactive hazards of various types of radioactive materials, including source, byproduct, and special nuclear materials (i.e., those currently regulated by the NRC), and Naturally-occurring or Accelerator-produced radioactive materials (NARM).[2] The portion of this law relating to the regulation of source, byproduct, and special nuclear materials is only effective, however, if the Commonwealth becomes a participant in the NRC's "Agreement State" program which transfers regulatory authority from that federal agency to the State. At the present time, Massachusetts is not an Agreement State, although the Commonwealth has made formal application to the NRC.[3]

Two other state laws relating to DPH authority over LLRW treatment are contained in Chapter 111H. Section 13 requires DPH to adopt regulations for "source minimization, volume minimization and storage for decay," all activities pertaining to treatment. The preceding chapter discusses these activities, and recommends a Massachusetts Source and LLRW Volume Elimination/Minimization Program for implementation by DPH.

In addition, section 16 of Chapter 111H requires DPH to adopt regulations incidental to treatment for any storage, treatment, or disposal facilities licensed under the law.

The Low-Level Radioactive Waste Management Board also has authority over LLRW treatment policy issues pursuant to various provisions of Chapter 111H:

(1) Section 12 authorizes the Management Board to develop, and adopt by regulation, a Management Plan to provide for the "safe and efficient" management (including treatment) of LLRW. Treatment policy is also related to requirements in section 12 for:

- the classification system developed by the Board (see Chapter 7);
- the review of treatment technologies and practices and the treatment-related recommendations contained in this chapter;
- the inventory of all radioactive materials users;
- the inventory of treatment facilities inside and outside the Commonwealth; and
- the required "finding" whether additional treatment facility capacity is necessary.

(2) If a storage, treatment, or disposal facility is sited and licensed in Massachusetts, section 33 of Chapter 111H authorizes the Management Board to institute treatment-related policy through the negotiation of a "comprehensive operating contract" with the site community and the facility operator.

(3) If such a facility is ready to operate, section 38 authorizes the Management Board to regulate

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[2] A description of these radioactive materials can be found in the glossary section at the beginning of this Management Plan.

[3] Additional information about the Agreement State program and the State's responsibilities under it can be found in Chapter 2.

treatment which promotes "source minimization, volume minimization and storage for decay" incidental to "waste acceptance fees" and "waste acceptance criteria" at the facility.

The Massachusetts Department of Environmental Protection (DEP) is the third state agency involved in treatment policy. As is noted in Chapters 2 and 8 of this volume, DEP has applied to the EPA for authority to regulate mixed waste under provisions of the federal Resource Conservation and Recovery Act (RCRA). Until that authority is granted, which is not expected until 1994 at the earliest (due to delays in the EPA review process), DEP can regulate mixed waste under existing state hazardous waste law, Massachusetts General Laws c.21C. These state regulations are essentially the same as the EPA's national regulations.

DEP treatment regulations specify that mixed waste generators may not transport mixed waste off site (for treatment or disposal) unless the generator (or transporter) has a valid DEP transport license. DEP regulations also require that generators may not ship mixed waste to any treatment facility unless the treatment facility has a DEP license or an EPA permit. In addition, any generators (except for those that produce less than 220 pounds of hazardous waste, and no "acutely hazardous waste," per month) who seek to treat mixed waste on site are regulated by DEP in the same manner as the operator of a hazardous waste treatment facility, and therefore must have a treatment facility license, approved by DEP.

In addition, DEP regulations stifle or prohibit outright the treatment of mixed waste by "storage for decay,"[4] because of the requirements pertaining to on-site accumulation of hazardous (i.e., mixed) waste. A "large quantity mixed waste generator (i.e., one who produces over 2,200 pounds per month of hazardous waste, or over 2.2 pounds per month of acutely hazardous waste) may not store mixed waste on site for more than 90 days without getting a DEP license to operate a hazardous waste "storage facility." A "small quantity" generator (i.e., one who produces over 220 pounds of hazardous waste or less than 2.2 pounds of acutely hazardous waste per month) may store mixed waste on site for any length of time, "at or near each specific point of generation," if a key staff person is directly responsible for each location, and if only one container (55 gallons of hazardous waste or one quart of acutely hazardous waste) is used at any one time. A "very small quantity generator" (i.e., one who produces less than 220 pounds of hazardous waste and no acutely hazardous waste per month) is exempt from DEP's on-site accumulation rule.

As a result of DEP's regulation, generators of mixed waste containing relatively short-lived radionuclides that could be treated, and essentially eliminated, by the storage for decay procedure, cannot take advantage of that benign treatment opportunity to reduce the radioactivity of their waste. This prohibition is in direct conflict with the policies of the NRC and the Management Board, which encourage storage for decay to the maximum extent possible.

Also, with the exceptions mentioned above, mixed waste generators who use other types of on-site treatment, such as solidification, stabilization, etc., are required to be licensed as operators of hazardous waste treatment facilities.

11.3 Existing Treatment Activities in Massachusetts

LLRW treatment occurs both on site where the waste is produced, and off site at treatment facilities,

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[4] "Storage for decay" is a procedure in which LLRW or mixed waste with a relatively short half-life is held for natural radioactive decay in compliance with applicable federal and state regulations. Once the radioactivity has decayed to below background levels, the waste is no longer considered LLRW, and can be disposed of as normal "solid" (or in the case of mixed waste, as "hazardous") waste.

which operate principally for the purpose of processing waste. In addition, some large LLRW generators that operate in more than one location in Massachusetts transport their waste to one site within their licensed facility where all LLRW from their various divisions is treated.

For the purposes of this section of the Management Plan, treatment is considered to occur "on site" at a waste producer's company or institution, or "off site" at a broker or processor's facility where waste is treated prior to being shipped for disposal.[5]

Most waste is treated, either on site or off site. Some waste receives "double" treatment, i.e., it is processed initially at the generator's site, and then again at a commercial treatment facility. Table 11-2 shows a comparison of on-site to off-site treatment of waste produced in 1991 and 1992.

Table 11-3 illustrates the percentage of LLRW generated in Massachusetts in 1991 and 1992 that received some form of treatment.

According to data from the annual survey of radioactive materials users, the most frequent types of treatment technologies used by LLRW generators in Massachusetts are incineration, compaction and

Table 11-2
Amount of Waste Treatment by Location, 1991 and 1992
(cubic feet)

	On Site		Off Site	
Generator Category	1991	1992	1991	1992
Academic	15,433	9,874	3,382	3,653
Commercial	27,472	21,806	20,424	28,565
Government	697	41	7.5	297
Health	16,263	18,150	3,441	2,876
Utility	44	446	35,068	28,544

Note: The figures do not correspond with those in Table 11-3 for two principle reasons: (1) Some survey data provided only the volume of waste after on-site compaction; the generators do not normally measure their volumes until packaged. (2) Much of the waste volume shown in Table 11-3 received treatment both on site and away from the generator's operation; therefore its volume is counted in both on-site and off-site treatment columns.

Source: Massachusetts Low-Level Radioactive Waste Management Board. 1991 and 1992 Massachusetts Low-Level Radioactive Waste Survey Reports. November, 1992, and October, 1993.

[5] Waste can also be treated out-of-state and shipped back to the company or institution where it was produced. This activity does not currently occur, because Massachusetts continues to have access to the Barnwell, South Carolina, disposal site, which accepts non-mixed waste after treatment. However, when the Barnwell disposal site ceases accepting Massachusetts LLRW, the waste will have to be stored on site unless licensees can arrange to have processors store the waste following treatment, or find other centralized storage facilities to serve this function. Many generators may decide to send their waste out-of-state for treatment in order to reduce the volume or make it otherwise safer for storage. The processed waste would then be returned to its rightful owner in Massachusetts.

Table 11-3
Volumes of LLRW Before and After Treatment, 1991 and 1992
(cubic feet)

Production\Disposition	Generator Category										Totals (two years)	% of Total
	Academic		Commercial		Government		Health		Utility			
	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992		
Produced	18,815	13,525	62,390	242,168	711	32,352	19,745	21,026	46,726	40,322	497,780	N/A
Waste Avoidance												
Placed in Storage	472	98	6,927	2,003	660	8	213	44	44	446	10,915	2.2
Storage for Decay	7,119	7,786	18,010	18,108	37	33	13,053	15,302	0	0	79,448	16.0
Incineration (In State)	2,285	1,646	297	15	0	0	1,747	1,495	0	0	7,485	1.5
Return to Manufacturer\Supplier	0	0	150	291	0	1	920	911	0	0	2,273	0.5
Recycle\Recover	0	0	23	155	0	0	0	0	0	0	178	0.0
Sewer Release	5,556	341	1,796	126,179	1	0	330	397	0	0	134,600	27.0
Atmospheric Release	2	0	270	2,675	0	0	0	0	0	0	2,947	0.6
Total	15,433	9,871	27,472	149,425	697	41	16,263	18,150	44	446	237,842	47.8
Broker\Processor Treatment												
Shipped to:	3,382	3,653	20,424	28,565	8	297	3,441	2,876	35,068	28,544	126,258	N/A
Shipped from:	1,410	1,276	7,153	6,760	8	297	1,430	977	6,531	2,173	28,015	N/A
Volume Eliminated	1,971	2,377	13,272	21,805	0	0	2,012	1,899	28,537	26,371	98,244	19.7
Shipment for Disposal	1,410	1,276	21,647	70,935	15	32,310	1,470	978	18,145	13,505	161,691	32.5

Note: In somes cases there is no change in volume due to the inability to obtain final treated volume from the processor, or inconsistencies in the reported data.
Source: Massachusetts Low-Level Radioactive Waste Management Board. 1991 and 1992 Massachusetts Low-Level Radioactive Waste Survey Reports. Boston, MA, November, 1992 and October, 1993.

decontamination. As can be seen in Table 11-4, off-site incineration processed 38,000 cubic feet into 1,833 requiring disposal in 1991, and 10,181 into 112 cubic feet requiring disposal in 1992. Off-site compaction treated 16,800 cubic feet, resulting in 7,247 requiring disposal in 1991, and 50,149 cubic feet resulting in 7,895 cubic feet in 1992. Decontamination reduced 6,400 cubic feet to 980 cubic feet for disposal in 1991. These treatment methods are used on site, as well, but not to the same degree.

Table 11-4
1991 and 1992 LLRW Treatment Results - by Treatment Method
(cubic feet)

Treatment Method	Shipped to:		Shipped from:		Volume Reduction[1]		Reduction Ratio[2]	
	1991	1992	1991	1992	1991	1992	1991	1992
Compaction up to 250 Tons	3,579.4	3,098.5	2,416.0	1650.7	1,163.4	1,447.8	1.5	7.9
Compaction up to 251-999 Tons	206.0	400.6	87.0	117.4	119.0	283.2	2.4	3.4
Compaction up to 1000-2500 Tons	307.5	250.6	142.0	108.7	165.5	141.9	2.2	2.3
Compaction above 2500 Tons	6,790.9	46,399.1	1,833.8	5,906.5	4,957.1	40,492.6	3.7	7.9
Incineration	38,885.0	10,181.4	5,684.4	111.9	33,200.6	10,069.5	6.8	91.0
Size Reduction	0.0	5.5	0.0	1.1	0.0	4.4	NA	5.0
Wet Oxidation	4.8	0.0	4.8	0.0	0.0	0.0	1.0	NA
Solidification	11.0	300.0	548.0	300.0	-537.0	0.0	0.0	1.0
Adsorption	19.5	7.5	12.0	7.5	7.5	0.0	1.6	1.0
Macro encapsulation	1.7	4.8	90.7	[illegible].8	-89.0	-3.1	0.0	0.6
Absorption	53.0	41.5	53.0	30.3	0.0	11.2	1.0	1.0
Sorting\ Segregation	16.0	0.0	15.1	0.0	0.9	0.0	1.1	NA
Dry Chemical Packing	13.5	31.4	13.5	31.4	0.0	0.0	1.0	1.0
Totals	49,888.3	60,720.8	10,900.3	8,273.3	38,988.0	52,447.5	4.6	7.3

[1] Volume Reduction = (Volume Shipped to - Volume Shipped from)
[2] Reduction Ratio = (Volume Shipped to / Volume Shipped from)

Source: Massachusetts Low-Level Radioactive Waste Management Board. 1991 Massachusetts Low-Level Radioactive Waste Management Survey Report, November 1992 and 1992 Massachusetts Low-Level Radioactive Waste Management Survey Report, October 1993

Individual Versus Group Treatment

With few exceptions, waste treatment in Massachusetts is handled on an individual generator basis. That is, each LLRW generator provides for his own separate treatment practices. Many generators have

contracts with "brokers" which arrange for off-site storage and treatment, prior to disposal. In addition, "processors" are companies that treat LLRW at a facility specifically designed and licensed for treatment. Trucks from the brokers or processors may pick up only one barrel of LLRW from one generator, and then another and so on in order for the trucks to be full when they embark on their trips to the out-of-state treatment facilities.

As was noted in the previous chapter, Harvard University's program at its Southboro campus manages LLRW for its members, a group of Harvard University and Harvard Medical School Affiliated Institutions that provide research facilities for Harvard programs. The Harvard treatment program includes storage for decay of up to 5,300 drums of LLRW, plus additional freezer capacity for decay-in-storage of animal carcasses. Waste is stored in fiber drums in two buildings at the University's Southboro facility. After the decay period has elapsed, the drums are inspected by x-ray to ensure that they do not contain materials that cannot be incinerated, and then they are shipped to a commercial incinerator. The University is also licensed to use its on-site incinerator for the treatment by incineration of LLRW that falls within the 10 CFR 20.2005 "exempt quantities" category. Incineration of exempt quantities is a routine practice followed by many hospitals in Massachusetts, as well.

Harvard University's arrangement is not commercially available to other generators in the Commonwealth. It is not similar to any known group treatment service in the country.

One commercial treatment operation exists in Massachusetts to launder radioactively-contaminated clothing, and is used by nuclear-powered electric generating plants and research laboratories throughout New England.[6] These two "group" operations -- Harvard University's private arrangement with its affiliated Institutions, and the commercial laundry -- are unique in Massachusetts, where all other LLRW generators treat their waste on site or ship it off site and out-of-state for treatment.[7]

These two "group" treatment operations, are not considered "licensed facilities" as defined in Chapter 111H for treatment of LLRW, because they existed before the passage of Chapter 111H in 1987. Since that time, the siting process required by Chapter 111H has not been utilized to identify land for a centralized facility for treatment activities.

A provision accompanying Chapter 111H when it became law in 1987 exempts these licensees from the law's complex requirements of locating sites for a centralized treatment facility. However, the language also authorizes the Management Board to evaluate, on a case-by-case basis, whether any licensee's application to amend an existing NRC license is "consistent" with the State's LLRW Management Plan. Such review by the Management Board would occur only if Massachusetts were to become an Agreement State, and DPH were assigned the authority to license radioactive materials users. The relevant provision of law states:

> "Nothing in this act shall prohibit the Department of Public Health from issuing a renewal license to any person lawfully holding a license to accept waste for treatment, storage or disposal as of the effective date of this act and any such person may apply to said department for an amendment of the terms and conditions of such license if the application for such amendment has been determined by the Low-Level Radioactive Waste Manage-

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[6] Interstate Nuclear Services in Springfield processes clothing worn by workers from nuclear-power facilities and research companies, in order to remove radioactivity so that the clothing can be reused.

[7] Waste treatment activities are frequently consolidated at a single location at firms that have more than one division or operating locale in the Commonwealth. This consolidation of treatment under one company or Institution is still considered "on-site" treatment.

ment Board to be consistent with the Management Plan adopted pursuant to section 12 of Chapter 111H of the General Laws." [Section 8 of Chapter 549, Acts of 1987]

11.4 Analysis of LLRW Treatment Technologies and Practices

The analysis of current and developing LLRW treatment technologies and practices, required by section 12(b)(2) of Chapter 111H, must include an evaluation of the following:

(1) the potential public health, safety, and environmental impacts of treatment technologies and practices;

(2) their climatic, geologic, hydrogeologic, or other requirements;

(3) their suitability[8] for the LLRW managed within Massachusetts;

(4) their cost-effectiveness;

(5) recommendations for regulatory or other actions to improve the safety or efficiency of treatment technologies and practices, and

(6) recommendations for regulatory or other actions to ensure that property values are maintained in the vicinity of any treatment facility.

This section includes an analysis of the first five areas listed above. The subject of (6) above is covered in Chapter 17 of this volume of the Management Plan.

(1) Potential Health, Safety and Environmental Impacts

There are a number of potential environmental, health, and safety impacts associated with the use of the various treatment technologies listed in Table 11-1. The impacts can be both positive and negative. The potential positive impacts of treatment include:

- Treatment may reduce the potential for radionuclides in the waste to be released during storage, transportation, or disposal.
- Treatment can remove or eliminate the radioactive contaminants or the hazardous chemical contaminants of LLRW (or both).
- Treatment can reduce the volume of waste requiring storage, transport, or disposal.
- Treatment can stabilize waste to reduce the potential hazards of waste in storage, transport, or disposal.
- Treatment can reduce the potential for waste to react negatively with its container, thereby enhancing the ability of the waste package to contain waste over a longer period of time.

[8] The word "suitability" is not defined in Chapter 111H. For purposes of this Management Plan, it is generally considered to reflect the concept of "appropriateness."

- Treatment technologies that render LLRW safer for management can reduce the potential that the waste could be a hazard to public health, safety, and the environment.

There are some negative health, safety, and environmental impacts of waste treatment, although they are considered to be small with properly designed and operated systems. Waste treatment requires additional handling and equipment operation, and potentially more packaging, and transportation. These activities have the potential to increase the doses to workers at the treatment, packaging, and transportation locations. If an accident occurred during transportation, a small possibility exists that members of the public could receive radiation exposure as a result. In addition, some treatment technologies concentrate activity in the process of reducing volume. Under some conditions, such concentrations of activity could increase the potential for health, safety, and environmental damage.

The potential negative impacts of <u>on-site</u> waste treatment include:

- Treatment technologies and practices that result in concentrating the amount of activity in the waste could result in LLRW that would be classified as GTCC – Greater than Class C waste. While the disposal of GTCC waste is a federal responsibility, potential adverse health, safety, and environmental impacts from processing, handling, and storing GTCC waste could occur.

- Greater waste handling could increase the potential that radiation safety workers may be exposed to larger doses of radiation, especially direct gamma radiation.

- Greater waste handling increases the possibility of spills and other releases to the environment.

- Some treatment processes involve the use of heavy equipment or toxic chemicals which, if improperly handled, could cause accidents leading to environmental releases, worker exposure, fires, or explosions.

The potential negative impacts for <u>off-site</u> treatment include those listed above as well as:

- Shipping LLRW to processors for treatment can increase the potential for accidents to occur en route. In addition, when the disposal site in South Carolina ceases accepting Massachusetts LLRW, generators may wish to continue sending waste to treatment facilities for processing, but will have to accept the waste back at their facilities in Massachusetts for interim storage until disposal capacity is available. If a large percentage of Massachusetts LLRW generators send their waste out of state for treatment, shipments returning to Massachusetts could increase waste transport on Massachusetts roads. While LLRW transportation has proven to be safe based on the insignificant national accident/incident rate,[9] a potential always exists for accidents to occur.

- A second set of radiation workers is exposed to the waste at the treatment facility, in addition to those at the site of generation.

- Health, safety, and environmental incidents have the potential to be more serious at an off-site treatment facility which batch processes larger quantities of waste and curies than exist at individual generator's locations.

Incineration has the potential to cause other negative environmental and health impacts. The incineration of LLRW produces gaseous effluent, which must be trapped and cleaned from filters to remove both the radioactive materials and any hazardous chemicals produced as a result of combustion. Some

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[9] Please refer to the transportation discussion in Chapter 9.

radioactive materials, like Carbon-14 and Hydrogren-3 (tritium), are more difficult to trap in the gaseous outflow, because incineration changes them to carbon dioxide and water, some of which may be released to the atmosphere during incinerator operation. Regulations control the concentrations of radionuclides in the effluent, and limit the total amounts allowed to be released to the atmosphere.

Nevertheless, new methods have been developed to reduce the potential impact from malfunctions and other effluent releases during the incineration process. Ash can be solidified with cement or polymers, or "vitrified," by mixing it with a glass material. Solidified incinerator ash is more stable than other types of LLRW. It is not flammable, not biodegradable, and if uncontrolled, could allow only a very slow release of radionuclides, if exposed to water. Transformation of radioactive materials into this form, therefore, could produce a waste disposal product that is more protective of the environment than the original waste form.

(2) Climatic, Geologic, Hydrogeologic, or other Requirements

As mentioned, most treatment technologies and practices, on their own, have the potential to cause minimal environmental consequences. In addition, these technologies, with the possible exception of incineration, have very few climatic, geologic, hydrogeologic, or other environmental requirements in terms of where they can be located.

The buildings that house the technologies need to be located in areas that are not environmentally sensitive, and must be engineered to provide multi-layer environmental protections (for example, floor drain collection). However, unlike long-term storage or disposal, the waste does not remain in a treatment process for very long. It therefore does not have the opportunity during the treatment process to leach into a water supply or contaminate the soil, if proper steps are taken at all times to prevent waste releases from the treatment units.

If a treatment "facility" were to be sited, developed, and operated in the Commonwealth to serve all or a group of LLRW generators, and utilize one or more of the treatment "technologies" identified in Chapter 10 of this Plan, it would be subject to certain environmental requirements, including:

- review of climatic, geologic, hydrogeologic, and other environmental conditions during the identification of a suitable site pursuant to DEP's regulations;
- review of these environmental criteria during detailed site characterization by the Management Board and the potential host community;
- environmental review (Environmental Impact Report) pursuant to the Massachusetts Environmental Policy Act requirements by the Executive Office of Environmental Affairs [Chapter 30, section 62], prior to licensure;
- knowledge of all waste to be treated and the side products that result due to different reactions and components;
- emissions standards relating to the release of radioactive isotopes set by the NRC and EPA/DEP; and
- facility design and performance specifications of any draft license issued by DPH pursuant to the requirements in section 31 of Chapter 111H.

In addition, if an LLRW treatment facility were to employ incineration to treat mixed waste, a "Part B" permit would be required from the EPA pursuant to RCRA [40 CFR Part 264, Subpart O and 40 CFR Part 265, Subpart O], and a license would be required from the DEP pursuant to the State's hazardous waste

facility regulations [310 Code of Massachusetts Regulations (CMR) 30.00]. The RCRA permit and DEP licensing requirements include detailed descriptions of environmental factors at the site.

(3) Suitability of Treatment Technologies for Massachusetts LLRW

Various health, safety, and environmental impacts -- both positive and negative -- have been described in the preceding subsections. Their suitability for waste managed within the Commonwealth depends on a number of factors, especially whether the technology of interest is to be used out of state, or to be constructed for use at an in-state site.

In general, the treatment technologies listed in Table 11-1 are suitable for LLRW managed in Massachusetts. Treatment can enhance some waste characteristics for subsequent waste management steps. Treatment allows some waste materials to be recycled or reused, and reduces waste volume for ultimate disposal. The need for fewer storage and disposal containers saves valuable space; and stabilized waste forms provide some advantages in handling, transport, storage, and disposal.

Moreover, LLRW generators are required to consider treatment options in order to comply with Chapter 111H:

> "to prepare and implement plans for the utilization of all appropriate source minimization, volume minimization and storage for decay methods." [section 13]

(4) Cost-Effectiveness

The requirement in section 12 of Chapter 111H for the inclusion in the Management Plan of an evaluation of "cost-effectiveness" of treatment technologies and practices pertains to cost-effectiveness from the Commonwealth's perspective.

Treatment on its own is an added cost to LLRW generators. However, treatment can partially offset other waste management costs, because the changes in the characteristics of LLRW that result from treatment generally lead to lower costs for packaging, storage, shipping, and disposal.

If treatment is not required to meet packaging, storage, shipping, or disposal criteria, then the treatment technologies are only cost-effective to the generators if the added costs are balanced by the savings obtained.

The evaluation of "treatment" cost-effectiveness to the Commonwealth depends upon the treatment requirement and the type of treatment practice. If treatment occurs at the site of generation, the direct costs of the treatment activity are borne by the waste producer through the costs of using processing equipment, materials, and additional labor. The Commonwealth's costs are indirect, and can include licensing costs, and the costs of permitting and inspecting the treatment operations. Other indirect costs to the Commonwealth may result from the effects of treatment on the costs and prices for goods and services from in-state LLRW generators with respect to out-of-state competitors. Significantly higher or lower treatment costs of in-state generators could affect their competitive position. In turn, the Commonwealth could be impacted in terms of jobs and revenues through this impact on businesses and employment.

If treatment occurs away from the site of waste generation, at an out-of-state processing facility, the indirect costs to the Commonwealth currently include the costs of randomly inspecting transportation shipments and providing emergency response, if required.

If LLRW treatment were to occur at a state-owned treatment facility, the State's costs would be

significant in comparison to its costs to monitor on-site treatment by generators, or treatment at a processor's location. A site for a treatment facility would have to be identified using the procedures required in Chapter 111H. Site characterization studies, licensing, environmental monitoring, and other factors would add to the State's costs of this treatment option.

A state-owned treatment facility built in conjunction with a state-owned disposal facility would add costs to facility construction and operation, and increase the disposal charge per package of LLRW requiring disposal. Treatment could, however, improve the stability and safety of the waste for disposal, and thereby reduce the potential of contamination to the public and the environment in case of a disposal accident. In addition, a combination treatment-disposal facility could decrease costs to generators who would not have to send their waste out-of-state for treatment prior to disposal.

Because federal LLRW laws do not include "treatment" in the federal definition of "management," states are not mandated by federal law to provide for LLRW treatment. As a result, few studies have been undertaken to assess the cost-effectiveness to states of developing treatment facilities.

One study was completed for the Central Midwest Interstate Low-Level Radioactive Waste Commission (Illinois and Kentucky) in 1987.[10] The study assumes that no out-of-region waste would be accepted for treatment, and only one centralized treatment facility would be in operation. An analysis was conducted to estimate the cost of treating LLRW using either supercompaction or incineration at a centralized treatment facility. The results are shown in Table 11-5, and have been adjusted to 1993 dollars. The study considered two scenarios:

(1) that existing treatment practices would continue for waste already being treated, or

(2) that all combustible wastes would be incinerated at the facility.

In the first scenario, only 27,000 to 30,000 cubic feet of the total 185,000 cubic feet of waste produced annually in the Central Midwest Region would be treated in the centralized facility. In the second scenario, 247,000 to 249,000 cubic feet of waste would be treated yearly at this regional facility.

The study found that the 30,000 cubic feet that would be treated at the facility under Scenario 1 would not be enough waste to fully utilize a supercompactor or incinerator. The volume of waste treated in Scenario 2, however, would require round-the-clock operation of the supercompactor or incinerator.

The study also estimated the cost per cubic foot of reduction in the volume of waste taken by a regional disposal facility. The costs, presented in Table 11-5, show that Scenario 2 results in a lower average cost per cubic foot of reduction in the volume of waste sent to the disposal facility.

In addition, Table 11-5 shows that developing a centralized incinerator facility under Scenario 1 would not be cost-effective because such a facility would raise the cost of treating the waste higher than the unit cost of disposing of it. This is due to the fact that the costs of developing and operating an LLRW disposal facility involve several high, fixed expenses, which cannot be eliminated by reducing the volume of waste entering the disposal facility. If incineration or some other treatment facility were developed, and generators continued to send some of their waste elsewhere for treatment, higher unit charges would be assessed against those that sent their waste to the facility.

The model described in the Central Midwest Compact Commission study is useful for the purpose

[10] Rogers and Associates Engineering Corporation. Potential Impacts of Source and Volume Reduction Techniques on the Central Midwest Compact's Waste Management System. October, 1987.

Table 11-5 Estimates of Treatment Costs to Reduce LLRW Volume in a Disposal Facility			
Scenario	**Annual volume entering treatment (cubic feet)**	**Cost per cubic foot of waste no longer requiring disposal as a result of treatment**	**Disposal cost per cubic foot of waste reduction**
1: Current treatment practices continue for waste that is presently treated:			
Supercompactor	27,000	$47	$81-$112
Incinerator	30,000	$141	$81-$112
2: All appropriate waste treated:			
Supercompactor	247,000	$12	$81-$112
Incinerator	249,000	$31	$81-$112

Note: Calculated in 1993 dollars.

Source: Rogers and Associates Engineering Corporation. Potential Impacts of Source and Volume Reduction Techniques on the Central Midwest Compact's Waste Management System. October, 1987.

of understanding the cost-effectiveness of treatment in relation to disposal. However, the results of this model are not necessarily transferable to the real costs of a Massachusetts treatment facility, due to the number of variables involved, including waste volume, waste characteristics, the number of LLRW generators needing such a facility, etc.

Many of the factors that must be considered in evaluating cost-effectiveness of treatment technology options are identified in the matrix shown in Table 11-6. In addition, factors to be considered in assessing cost-effectiveness of treatment practices (e.g., on-site/generator arranged versus state-owned centralized facility) are shown in Table 11-7. While these matrices are not meant to be all inclusive, they represent the type of analysis that must be completed to determine the treatment technologies and practices that are most cost-effective, if the Commonwealth were to pursue the siting of a centralized treatment facility.

For example, the Management Board would want to assess the cost-effectiveness to the Commonwealth of utilizing one or more treatment technologies and practices that could increase the concentrations of radioactivity in the waste beyond the limits set for Class A, B, or C LLRW, thereby moving the treated waste into the Greater than Class C (GTCC) category. The evaluation of such treatment endeavors would depend upon the ability of generators to dispose of GTCC waste, which is a federal responsibility.

Estimates of each activity and option need to be inserted into the matrix and then totalled to identify the most cost-effective solution. These costs need to be presented on a present value basis[11] to provide an accurate comparison.

Once that exercise is completed, other factors such as the economic viability of Massachusetts radioactive materials users, as well as environmental and political considerations, must also be considered.

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[11] "Present value" is the amount of money which, if invested at risk-free interest rates today, will compile enough interest so that the sum of the principal plus the accrued interest will equal the required future costs.

Table 11-6 Factors Relative to Cost-Effectiveness of Certain Treatment Technologies				
Factors affecting treatment costs	**Incineration**	**Compaction/ Supercompaction**	**Ion Exchange**	**Storage for Decay**
Packaging	X	X	X	X
Chemical Additives			X	
Equipment	X	X	X	
Licensing	X	X	X	X
Construction Costs	X	X	X	X
Operating Costs	X	X	X	X
Transportation	X	X	X	
Volume of Waste Requiring Treatment	X	X	X	X
Waste Characteristics	X	X	X	X
Health Risks:				
Doses to Public:	X	X	X	X
Doses to Workers:	X	X	X	X
Impact on Industry Competitiveness	X	X	X	X

Note: Depending upon whether the treatment technologies listed are used on site or off site, the effect of certain factors would change. For example, on-site storage for decay does not involve an analysis of transportation costs. However, off-site storage for decay does require such a cost analysis.

11.5 Recommendations to Improve Safety or Efficiency

The recommendations in this section are based upon the factors discussed earlier in this chapter relative to potential health, safety and environmental impacts of treatment; its environmental requirements; its suitability for LLRW managed in Massachusetts; and its cost-effectiveness.

General Recommendations

Encourage LLRW Treatment. Because LLRW treatment may make waste safer for other management steps, amenable for recovery, convertible to another usable material or reduced in volume, the Commonwealth should encourage LLRW treatment as appropriate in consideration of the public health, environmental, and economic impacts that treatment technologies and practices can effect.

Lower risks from treatment. Massachusetts recognizes the possible negative impacts on health, safety, and the environment of using treatment technologies and practices. However, the Commonwealth should inform the public that treatment technologies and practices can create potential risks of occupational and public exposure for the short-term in contrast to the long-term problems that unstabilized and untreated waste possibly could cause within an LLRW disposal facility.

Table 11-7
Factors Relative to Cost-Effectiveness of Treatment Practices

Factors affecting treatment costs	Treatment arranged by generator		State-owned, centralized treatment facility[a]	
	Cost to generator	Cost to state[b]	Cost to generator	Cost to state
Type of Treatment Technology	X		X	X
Volume of Waste Requiring Treatment	X		X	X
Waste Characteristics	X		X	X
Waste Segregation	X		X	X
Site Selection	X			X
Land Acquisition	X			X
Licensing	X	X	X	X
Environmental Review	X	X	X	X
Design	X			X
Operating Costs	X			X
Manpower	X		X	X
Personnel Monitoring	X		X	X
Environmental Monitoring	X	X	X	X
Re-Packaging	X		X	X
Equipment	X		X	X
Health Risks:				
Doses to Public:	X		X	X
Doses to Workers:	X		X	X
Closure Costs	X		X	X
Institutional Control Costs[c]			X	X
Decommissioning	X		X	X
Transportation	X		X	
Community Impact Payments	X		X	X
Construction Costs	X		X	X
Amortization	X		X	X
Interest Costs	X		X	X
Inspection		X	X	X
Special Handling	X		X	X

Table 11-7 Factors Relative to Cost-Effectiveness of Treatment Practices (continued)				
Factors affecting treatment costs	Treatment arranged by generator		State-owned, centralized treatment facility[a]	
	Cost to generator	Cost to state[b]	Cost to generator	Cost to state
Liability	X	X	X	X
Waste Acceptance Criteria[d]			X	
Emergency Preparedness and Response		X	X	X
ALARA[e]	X		X	X
Training	X	X	X	X
Impact on Industry Competitiveness	X	X	X	X

[a] Costs assigned to both generator and the State for a state-owned, centralized treatment facility are assumed to be shared in some fashion between generators and the State. State costs could be recovered through user fees.
[b] Assumes Massachusetts is an Agreement State, and, therefore, has direct responsibility for oversight and enforcement of licensees.
[c] The institutional control period that may be required for a centralized treatment facility may not conform to the period of institutional control required for a disposal facility, since the treated waste is not left at a treatment site for extended periods.
[d] "Waste Acceptance Criteria" are the requirements that must be annually approved by the Management Board (upon submission by the facility operator) for the receipt of LLRW at a centralized treatment facility operated pursuant to Chapter 111H.
[e] "ALARA" denotes the concept "as low as is reasonably achievable" in ensuring low radiation dose to workers and the public, and is a requirement of the NRC.

Minimize sources and LLRW volumes through treatment. Treatment for the purposes of source and waste volume minimization and storage for decay is required for all LLRW generators, pursuant to Chapter 111H. Minimization programs for licensees should be developed consistent with the recommendations made in Chapter 10 and Appendix 10A.

Treatment for stabilization. In addition to waste minimization, treatment should be encouraged by the Commonwealth for the purpose of stabilizing waste, especially as the out-of-state disposal site in South Carolina prepares to cease accepting Massachusetts LLRW.

Exchange information on treatment. In encouraging and promoting minimization and stabilization, Massachusetts should serve as a resource to assist LLRW generators, to provide a technology exchange clearinghouse, and to provide information for all interested parties on the positive effects of LLRW treatment.

Encourage use of out-of-state treatment. The Commonwealth should encourage Massachusetts LLRW generators to utilize out-of-state treatment facilities, whenever appropriate. With respect to out-of-state treatment technologies and practices, the State presumes that the host states for these facilities have made judgments that the positive impacts of treatment outweigh any potential negative impacts.

Provide technical advice. LLRW generators should receive technical advice and support from the Commonwealth to aid in recognizing which treatment technologies and practices may not be appropriate for later waste disposal. For their part, generators must evaluate their individual treatment needs in light of the particular waste types and volumes they produce.

Recommendations to Ensure Environmental Protection

Evaluate environmental conditions. Climatic, geologic, and hydrogeologic considerations are relevant to both the siting of a centralized treatment facility and the analysis each LLRW generator must undertake to evaluate various on-site treatment technologies and practices.

Review of incineration techniques. Source reduction and elimination, where possible, waste volume minimization, and waste stabilization can be achieved to a maximum extent for numerous LLRW streams through various incineration treatment techniques, as are noted in Chapter 10. However, these techniques, ranging from the conventional "mass burn" incinerators to the latest state-of-the-art "super criticality" oxidation systems, require the review of a greater number of environmental licensing and permitting issues (e.g., air as well as potential land discharges, etc.) than other treatment techniques.

A small number of incineration facilities exist in the country that are capable of processing all of the nation's commercial LLRW.[12] As a result, the Management Board should consider the in-state siting of new facilities to utilize conventional forms of incineration, only if a determination is made that out-of-state incinerators will no longer be available to treat LLRW produced in Massachusetts in an economically justifiable and environmentally acceptable manner.

Recommendation to Ensure Environmental Protection, Public Safety, and Occupational Safety

Add DPH personnel for Agreement State implementation. In connection with recommendations by the Management Board and DPH that Massachusetts seek Agreement State authority,[13] the Commonwealth should provide an adequate number of qualified personnel in DPH to ensure the capability to conduct inspections and enforce regulations regarding treatment technologies and practices. The Management Board believes such personnel will cost less to the licensed community than current NRC fees, and will enhance the inspection and enforcement capabilities of the Commonwealth.

Recommendation to Ensure Treatment Technology Operational Safety, and Occupational Safety

Provide technical assistance on treatment technologies. The Commonwealth should provide LLRW generators technical assistance regarding treatment technologies and practices that may be most beneficial to individual generators. Such assistance should be available through a combination of agency sources: DPH, the Office of Technical Assistance which is implementing the Massachusetts Toxic Use Reduction Act, and the Management Board.

Recommendation for Action to Ensure Economic Protection for the Commonwealth

Monitor progress of GTCC facility. As consideration is given to present or future needs to site, develop, and operate an LLRW treatment facility in the Commonwealth, the Management Board will continue to monitor the federal government's progress to establish a disposal facility for Greater than Class C (GTCC) waste, as such a federal facility will affect the Chapter 111H requirements to determine appropriate waste acceptance criteria for a treatment facility.

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[12] Please refer to the discussion of the need for additional treatment capacity within the Commonwealth contained in Chapter 15.

[13] Other recommendations regarding Agreement State status appear in Chapter 2.

Recommendations for Regulatory Actions to Ensure Safe and Efficient Treatment Technologies and Practices

Management Board recommendations on S/WVM/E. DPH regulations to establish and implement a program of minimization and elimination, where possible, of radioactive sources and LLRW volumes should include the recommendations offered by the Management Board and contained in Chapter 10 and Appendix 10A.

Management Board review of license amendments. If Massachusetts becomes an Agreement State and assumes NRC regulatory authority over all radioactive materials users, with the exception of the nuclear-powered utility companies, the Management Board will fulfill its responsibilities under section 7 of St. 1987 c.549. That law provides a procedure for the Board to review applications from radioactive materials users wishing to amend their licenses to possess, use, store, treat, or dispose of, radioactive materials (and LLRW) -- in order for the Board to determine whether the proposed license amendments are "consistent" with the Management Plan. Because Chapter 549 refers to licenses issued by DPH -- and not NRC, this Act is operative only if Massachusetts is an Agreement State. In addition, it applies only to license amendments proposed after Dec. 8, 1987, the date Chapter 111H took effect. The review does not, therefore, apply to license amendments prior to that date.

11.6 Chapter References

Massachusetts Department of Environmental Protection. 310 Code of Massachusetts Regulations 30.00: Hazardous Waste Regulations. Boston, MA: December, 1990.

Massachusetts General Laws, Chapter 111H. Low-Level Radioactive Waste Management Act. Boston, MA: December, 1987.

Massachusetts Low-Level Radioactive Waste Management Board. 1991 Massachusetts Low-Level Radioactive Waste Survey Report. Boston, MA: November, 1992.

Massachusetts Low-Level Radioactive Waste Management Board. 1992 Massachusetts Low-Level Radioactive Waste Survey Report. Boston, MA: October, 1993.

Oak Ridge National Laboratory. Low-Level Radioactive Waste Treatment Technology. DOE/LLW-13TC. Idaho Falls, ID: National Low-Level Radioactive Waste Management Program, July, 1984.

Rogers and Associates Engineering Corporation. Potential Impacts of Source and Volume Reduction Techniques on the Central Midwest Compact's Waste Management System. Springfield, IL: Central Midwest Interstate Low-Level Radioactive Waste Commission, October, 1987.

U.S. Nuclear Regulatory Commission. Title 10, Code of Federal Regulations, Parts 20 and 61. Washington, DC: U.S. Government Printing Office, 1991.

Chapter 12: Providing Storage Capacity for LLRW Generated in Massachusetts

12.1 Introduction

This chapter, like the previous one discussing low-level radioactive waste (LLRW) treatment technologies and practices, reviews and analyzes LLRW storage technologies and practices according to their potential health, safety, and environmental impacts; their climatic, geologic, and hydrogeologic requirements; their suitability for LLRW managed in the Commonwealth, and their cost-effectiveness. An evaluation of these issues is required by Massachusetts General Laws, c.111H (Chapter 111H), the State's Low-Level Radioactive Waste Management Act.

This chapter also summarizes federal and state regulations pertaining to LLRW storage, and "interim and emergency" storage, and makes recommendations to improve the safety or efficiency of storage technologies and practices, on the premises of LLRW generators and at a centralized LLRW storage facility.

The chapter that follows this one contains a similar evaluation of the technologies and practices for LLRW disposal.

12.2 LLRW Storage Technologies and Practices

"Storage" is defined as the "holding of LLRW for treatment or disposal." [Chapter 111H, section 1] Storage may occur at the site where the LLRW was generated; off site at the location of a broker or processor;[1] at a storage facility; or at an LLRW disposal facility prior to disposal.

Storage at the site where waste is generated typically has lasted only for short periods of time. This has been due to the availability of disposal sites and the desire of LLRW generators to package, transport, and dispose of their LLRW for safety and regulatory reasons, as well as before costs for all these services increase -- which they have done on numerous occasions over the years.

Some LLRW generators, however, produce so little waste each month that they do not fill a single disposal container or comprise enough for an LLRW shipment. Therefore, they typically store their waste until enough waste has accumulated to comprise one container, or one shipment.

The case study of a shipment of Hydrogen-3 (tritium) described in Appendix 9A of Chapter 9, the chapter on transportation and packaging, is an example of a radioactive materials user that stores waste until enough has accumulated to comprise one shipment. E.I. Du Pont De Nemours and Company, which

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[1] A "broker" arranges for the packaging, storage, transportation, treatment, or disposal of LLRW. A "processor" treats the waste to prepare it for storage, transportation, and/or disposal.

manufactures radioactive products used by hospitals and other medical institutions, stores tritium for approximately four months until it has enough to send one shipment to a disposal site.

Another exception to the practice of short-term on-site storage is "storage for decay," a procedure detailed in Chapter 10 of this volume as a method to minimize LLRW. Storage for decay allows LLRW containing relatively short half-life[2] material to be stored, most often at the site of generation, to allow the natural radioactive decay process to occur. What remains is waste with levels of radiation less than the background radiation we receive daily from the sun's rays, the earth, and other natural sources. When the decay process is complete, the essentially non-radioactive waste can be disposed as solid waste.

In the 1970s, when LLRW disposal costs were relatively low, many hospitals and other licensed radioactive materials users shipped for disposal waste containing both short and long half-life radioactive materials. Less consideration was given to storage for decay as a treatment technique until disposal charges and transportation fees escalated.

On-Site Storage Limited by License

Restrictions set by the U.S. Nuclear Regulatory Commission (NRC) in the licenses it issues to Massachusetts users of radioactive materials place limitations on the radionuclides and their activity (measured in curies) that may be stored on site. By confining the license period to the time in which only short-lived material can decay to background levels of radiation, all waste contaminated with radionuclides of longer-lived material must eventually be sent to a disposal site.

In guidance notices to its licensees, the NRC limits license periods to a maximum of five years, in order to evaluate the licensees' compliance with various NRC regulations before granting license extensions. This five-year limit is also the maximum time the NRC will allow storage to occur on site. Most commercial licenses are granted for two to three years, which restricts the radionuclides that may be stored for decay to those with half-lives less than 90 days, since they will generally decay to background levels within three years. Other radionuclides have to be transported to an LLRW disposal site once the storage period authorized in the license is over.

NRC regulations allow one exception to their five-year maximum on-site storage policy for nuclear-powered electric generating plants, due to the fact that much of the waste these plants produce is "high-level radioactive waste" (HLRW)[3] which is being stored on site because no national HLRW disposal facility exists. Power plant waste may be stored at the facility for the entire license period of the plant's operation (up to 40 years) if the plant's "safety analysis report" has been approved by the NRC, and storage does not involve a "change in the technical specifications incorporated in the license or an unreviewed safety question." [Title 10 Code of Federal Regulations (CFR) Part 50.59]

The NRC has been concerned about the increased reliance on on-site LLRW storage in view of the mandates of the federal Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) that require states

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[2] The "half-life" of a radioactive substance is the amount of time it takes for half of the substance to decay away. For example, two curies of Molybdenum-99, a radioactive substance used in medical diagnosis and treatment, will decay to one curie in 67 hours, the half-life of this radionuclide. After 10 half-lives or 670 hours (approximately 28 days), only 0.001953125 curies remain.

[3] The distinctions between HLRW, LLRW, and other types of radioactive wastes are described in detail in Chapter 4 of this volume. HLRW and "spent nuclear fuel" are defined separately in the federal High-Level Waste Policy Act, but are both considered HLRW by the NRC for management and disposal purposes. The management and disposal of HLRW is the responsibility of the federal government, not state government.

to assume responsibility for LLRW disposal by Jan. 1, 1993, and that allowed the three commercial disposal sites in Beatty, Nevada; Barnwell, South Carolina; and Hanford, Washington, to cease their availability as sites for the entire nation as of Dec. 31, 1992. Knowing of the three states' intentions to end their national waste acceptance policy, in January, 1992, the NRC proposed to restrict all generators, including nuclear-powered utility plants, to the maximum of five years of on-site storage. Nevertheless, Massachusetts and other states have instructed their LLRW generators to prepare for on-site storage in the near future.

Longer-Term Storage

Besides the relatively short period of on-site storage traditionally utilized by generators to accumulate enough waste to ship for disposal, and storage for decay, two new storage periods are emerging in plans being developed by LLRW management officials in Massachusetts and other states. These storage phases are referred to as "interim" storage and "long-term" storage. Interim storage lasts up to five years, while long-term storage exceeds five years.

Interim and long-term storage has become necessary due to the lack of disposal capacity available nationally, which is forcing more and longer periods of on-site storage. The Nevada site closed on Dec. 31, 1992. The Hanford, Washington, site remains open only to member states in the Northwest and Rocky Mountain Compact regions, as of that same date. South Carolina's site remains open to generators within the Southeast Compact region through 1995, and to out-of-region generators in certain states through June, 1994, at the latest.[4] The states that have access to the Barnwell disposal site include Massachusetts; the Low-Level Radioactive Waste Management Board successfully executed a contract with the regional compact entity controlling Barnwell. However, access to this site ceases on June 30, 1994.

In preparation for this June, 1994, loss-of-access date, the Management Board has notified all Massachusetts LLRW producers (since 1989) that they must prepare for on-site interim storage until the Commonwealth has developed an in-state or out-of-state disposal solution.

Types of Storage Technologies

The "technologies" used for LLRW storage involve the types of packaging in which the waste is placed and any additional structural barriers of protection. Various treatment methods, discussed in detail in Chapter 10, can also enhance the safety of storage.

In the case of LLRW categorized as "low specific activity,"[5] such as most of the waste produced by hospitals, universities, and commercial LLRW generators in Massachusetts, the containers holding the waste can prevent the release of radiation. The container itself serves as the major shield from radiation exposure. When the waste in the container receives another layer of protection by being placed in an

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[4] The contract agreement allows the Southeast Compact Commission, which controls access to the Barnwell site, to terminate the contract if it determines that a state (or regional compact) is not making "sufficient progress" towards providing LLRW disposal capacity.

[5] "Low specific activity" (LSA) material is radioactive material such as uranium or thorium ores, unirradiated natural or depleted uranium or unirradiated natural thorium, and tritium oxide in aqueous solutions not exceeding 5.0 millicuries concentration per milliliter. It is also waste in which the radioactivity is essentially uniformly distributed throughout, and the estimated average concentrations do not exceed specific millicurie-per-gram limits depending upon certain values (A_1) established in U.S. Department of Transportation (DOT) regulations. Additional information on the LSA category of waste can be found in Chapter 9.

isolated, restricted area inside or outside a building, the LLRW containers should present no significant health hazard.

Some waste with high specific activity can also be stored this way, because the radiation does not escape from the container. Waste contaminated with high concentrations of Hydrogen-3 and Carbon-14 are examples of high specific activity wastes that can be stored in this manner.

LLRW with high levels of radiation, such as much of the nuclear power plant wastes, require additional barriers of protection, called "shielding," in addition to the protection provided by the waste container, in order to reduce radiation exposure. Shielding can be accomplished by placing the same package type used for lower specific activity wastes in "overpacks" or "casks," or in specifically designed storage buildings.

These higher radiation-level wastes also can be stored in more protective packages, called High Integrity Containers (HICs), which are specially-designed concrete and steel-reinforced packages offering radiation protection for Class B and C wastes. (Please refer to the discussion of packaging types in Chapter 9.)

A frequently used storage procedure involves placing small penetrating radiation sources into small, high-density packages made of lead, steel, or cement, and then placing these packages into the centers of 55-gallon drums.

Other storage "technologies" include:

- Unshielded storage sheds or outdoor concrete pads that may be fenced but provide little or no protection from the environment, but whose distance from public contact eliminates the potential for radiation exposure. This type of storage is generally used only for very short-term storage, when waste packages are awaiting pick-up by a waste processor or broker.

- Unshielded buildings that provide some protection from the weather. This type of storage building is generally used for low specific activity wastes and for storage for decay.

- Shielded storage modules or bunkers which are permanent concrete "boxes" possessing removable concrete covers. A crane is used to lift the waste up into the structure, and also to remove it. Shielded "casks" are similar outdoor weather-tight concrete containers, but cylindrically-shaped rather than rectangular.

- Engineered buildings that are designed for the specific purpose of LLRW storage. Generally, these buildings are built of reinforced concrete or steel, and are divided into separate areas for the storage of low activity wastes and higher activity wastes. Higher radiation waste packages are frequently moved with overhead bridge cranes.

12.3 Storage Regulations

LLRW storage is regulated at the federal level by the NRC. In addition, the U.S. Environmental Protection Agency (EPA) regulates the storage of "mixed" waste, that small amount of LLRW containing materials listed as, or exhibiting the characteristics of, toxic chemical "hazardous" waste. When Massachusetts becomes an Agreement State and assumes the NRC's regulatory authority over all licensees

(except the nuclear power plants), storage will be regulated by the Department of Public Health (DPH).[6]

In addition, some regulatory control may be exercised by the Management Board in connection with its authority to regulate the conditions of access to any storage, treatment, or disposal facility licensed under Chapter 111H.

The NRC does not have regulations relating to short-term, interim or long-term storage. General regulations relating to labeling waste containers as well as the areas where radiation exists, the types of packaging that may be used for transportation and disposal, etc., all relate to waste that may be stored for an unstated period of time, while awaiting shipment to a disposal facility.

However, as noted, through licensing actions, the NRC limits storage to no more than five years, and authorizes individual storage periods in each license. The NRC has issued four guidance documents on storage to evaluate licensees' storage activities. A fifth issuance was published as a proposed new NRC rule in February, 1993. It has not yet been adopted.

The first two NRC guidance documents, officially titled "Generic Letters," relate to storage by nuclear power companies. The second two, termed "information notices," relate to storage by all other radioactive materials users (hospitals, universities, biotechnology companies, research institutions, and industrial operations).

These four NRC guidance documents and the proposed on-site storage rule are summarized below.

Generic Letter 81-38. This first storage guidance was issued in November, 1981, in response to several states' requests that the NRC allow utilities to store more LLRW than their licenses allowed, or to store their waste for a period exceeding five years.

The guidance letter emphasizes NRC's interest in ensuring radiological safety, and identifies design and operational requirements for "interim contingency storage" which pertain to waste form, concentrations in waste containers, total amount of radioactivity to be stored, the duration of storage, and waste retrievability. The NRC states that "prior to any implementation of additional on-site storage, substantial safety review and environmental assessments should be conducted to assure adequate public health and safety and minimal environmental impact."

Specifically, this NRC guidance requires:

- If possible, additional storage should be located inside the plant protected area.[7] If not possible, the storage facility should be placed on the plant site, and both a physical security program (fence, locked gates, alarms, patrols) and a restricted area for radiation protection should be established.

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[6] In July, 1992, Governor William F. Weld applied to the NRC for authorization to become an Agreement State, and thereby take over regulatory responsibility from the NRC. The Agreement State program, and its requirements on states, is discussed in detail in Chapter 2. The Massachusetts Department of Environmental Protection (DEP) has applied to the EPA for authority to regulate mixed waste, as is noted in the mixed waste discussion in Chapter 8. In the interim, however, DEP has statutory authority to regulate mixed waste under the State's hazardous waste regulations.

[7] The "protected area" means an area encompassed by physical barriers and to which access is controlled. [10 CFR 73.2(g)]

- Storage facility design and operation should assure that radiological consequences of design basis events (i.e., fires, tornados, seismic events, floods), should not exceed 10% (i.e., no more than a few rem whole body dose[8]) of the requirements in 10 CFR Part 100, which are the NRC's criteria for evaluating the suitability of nuclear power reactor sites.

- The added storage capacity should accommodate no more LLRW than the amount generated during a nominal five-year period.

- The volume and activity of waste in storage (measured in cubic feet and curies) evaluated for the storage location design should be determined from historical waste generation rates for the power plant, considering both minimization programs and plant operations that may generate unusually large amounts of waste.

- The quantity of radioactive material allowed for interim storage and the provisions for shielding that material will be dictated by the dose rate criteria for both (1) the site boundary and (2) unrestricted areas on site.[9]

- On-site dose limits associated with Interim storage will be the same limits set by the NRC's 10 CFR Part 20 for using radioactive materials. (Please see discussion of dose limits in Chapter 3.)

- The choice of storage containers should be based upon data that demonstrate that minimal corrosion will result from the environment (both internal and external) for a time period "well in excess" of the duration of storage.

- Containers must have sufficient integrity to allow waste handling, transportation, and disposal without breach.

- Certain wastes that can exhibit potentially flammable or explosive characteristics over time must be stored in containers equipped with special vents to allow depressurization.

- A minimum of quarterly visual inspections should be done to ensure container integrity. Packages designed to isolate waste for 300 years or more (i.e., HICs) would require a less-intensive inspection program.

- Wet radioactive waste is discouraged from storage because of the greater difficulty in managing liquids or wet solids. The NRC encourages nuclear power plant generators of wet waste to process this waste for ultimate disposal before it goes Into Interim storage. If storage is necessary before the wet waste can be treated and de-watered:

    a. Tanks should be designed to prevent uncontrolled releases or spillage.

    b. Tanks should be housed in structures designed with foundations and walls that meet seismic

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[8] A "rem" is a measure of the dose of any ionizing radiation to body tissues in terms of its estimated biological effect. "Whole body dose" is to be interpreted to mean "effective dose equivalent" wherever it appears in this Management Plan. The former term is used in many regulations and documents cited herein, and is retained in the text for consistency with these documents. The latter term represents recent changes in expressing dose.

[9] An "unrestricted area" is any area of a power plant in which access is <u>not</u> controlled by the licensee for purposes of protecting individuals from exposure to radiation and radioactive materials.

criteria, and to prevent the waste from release to the environment in a case of a tank or container failure.

c. Any spilled wet waste should be collected in floor drains.

d. Tanks and containers for wet waste must have overflow alarms.

In addition, Generic Letter 81-38 advises nuclear power companies that any application they submit for long-term storage also must follow the procedures and rules that apply to non-nuclear power radioactive materials users (hospitals, universities, Industry, etc.) [10 CFR Part 30, "Rules of General Applicability to Domestic Licensing of By-Product Material,"][10] as those regulations relate to:

- container Integrity;
- retrievability;
- volume reduction;
- Influence on state planning for disposal; and
- implications of de facto on-site disposal.

The NRC will issue a long-term storage license only for a "five-year, renewable term."

Generic Letter 85-14. The second guidance to nuclear-powered electric generating facilities was issued in August, 1985, in response to inquiries from some states for NRC approval of commercial storage facilities in place of disposal operations, and the use of nuclear power reactor sites as storage locations.

In issuing this Generic Letter, the NRC explicitly stated its opposition to using storage facilities as "de facto disposal sites." Nevertheless, even though the agency discourages it, such storage is allowed. However, in addition to "safe siting and operation," the NRC requires commitments and assurances for the eventual disposition of all waste, including provisions for any necessary repackaging, transportation, disposal, and decommissioning.

As for allowing non-utility waste to be stored at a nuclear power reactor site, the NRC view is clear:

> "As a matter of policy, the NRC is opposed to any activity at a nuclear reactor site which is not generally supportive of activities authorized by the operating license or construction permit and which may divert the attention of licensee management from its primary task of safe operation or construction of the power reactor."

The NRC also declared its jurisdiction over any such storage in the exclusion area[11] of the reactor

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[10] The NRC recently acknowledged its lack of authority to require utility LLRW generators to follow the regulations pertaining to non-utility radioactive materials users for long-term storage applications. This is a case where NRC's policy in a "generic letter" is not the same as the agency's regulations. The agency is therefore evaluating modifications to Generic Letter 81-38.

[11] The "exclusion area" means the area surrounding the reactor, in which the reactor licensee has the authority to determine all activities including exclusion or removal of personnel and property from the area. [10 CFR 100.3(a)]

site, regardless of whether or not the reactor is located in an Agreement State. If a state is an Agreement State, the state has the authority to license an interim storage facility for non-utility waste located <u>outside</u> the exclusion areas.

An application for storage of non-utility LLRW at a nuclear power plant site would require:

- A determination by the utility licensee that the proposed LLRW storage activities "do not involve a safety or environmental question, and that safe operation of the reactor will not be affected." In making this judgment, the licensee must consider:

  a. direct impacts of storage operations on reactor operations;

  b. the diversion of management and personnel attention away from reactor operation;

  c. the combined effects of on-site and off-site exposure during normal and accident conditions;

  d. the impact of storage on the effectiveness of reactor emergency plans and security plans;

  e. the impact of storage on financial liability; and

  f. the environmental impact of the storage facility.

- The applicant for the storage facility, which may be a state or a utility, must also provide:

  a. information relating to the safety and environmental impact of the storage operation;

  b. financial assurance during operation and decommissioning of the storage facility, including any necessary repackaging, transportation, and waste disposal; and

  c. written agreement from the state that it will accept waste from this storage facility for ultimate disposal.

- The NRC will conduct an environmental assessment and, most likely, issue an Environmental Impact Statement based upon the assessment.

No application has been made, to date, to the NRC for approval to license a long-term centralized storage facility at either a power reactor site or a non-utility site.

<u>Guidance for Storage by Other LLRW Generators</u>

The NRC's two "information notices" providing guidance for storage by non-utility radioactive materials licensees include Information Notice 89-13, which suggests actions by radioactive materials licensees if they are restricted from the use of disposal sites, and Information Notice 90-09, which discusses extended interim storage.

<u>Information Notice 89-13</u>. This notice was issued in February, 1989, following the denial of access to LLRW producers in New Hampshire, Vermont, and Michigan to disposal sites in South Carolina, Nevada, and Washington. It suggests that the radioactive materials users in those states:

- review their current NRC licenses and determine if changes are necessary to allow for increased LLRW storage;

- determine what portions of their waste goes to a disposal facility through a waste broker, since those portions must be added to the total waste requiring storage;

- evaluate safety problems that potentially could occur due to longer periods of storage, such as package deterioration, inventory control, fire hazards, etc.;

- evaluate minimization techniques to reduce radioactive sources and waste volumes, such as storage for decay, returning unneeded sealed sources to the manufacturers, on-site or off-site waste processing (incineration, compaction, etc.), or off-site interim storage facilities.

Information Notice 90-09. The last and most recent NRC guidance on storage for those licensed to use radioactive materials was issued in February, 1990, as a parallel policy guidance to the agency's two Generic Letters to utility licensees. It recommends actions that licensees should follow to ensure they are authorized for storage "for anywhere from several months to several years."

While NRC uses different terminology to describe interim storage for utilities (i.e., "interim contingency storage") and interim storage for other radioactive materials users ("extended interim storage"), the agency's policy on the term of the storage period is the same: no greater than five years. NRC's recommendations on safety and operational issues involved in storage are the same in Information Notice 90-09 as they are in Generic Letter 81-38:

- Other than storage for decay, storage is no substitute for disposal.

- Waste should be processed prior to storage, packaged in a form ready for transport and disposal, and labeled in accordance with NRC requirements for labeling containers and radiation areas.

- Waste in interim storage should be protected from the weather and extremes of temperature and humidity.

- Quarterly inspections of the interim storage area must be undertaken.

- Procedures and equipment may be necessary to repackage waste for disposal.

- Chemical properties of some wastes (e.g., hazardous, corrosive, flammable, biologic, etc.) necessitate an evaluation of treatment activities required to prevent such reactions before the waste is placed in storage.

- Licensees must evaluate their waste and their plans for a storage location to determine if additional shielding is necessary to reduce worker exposure.

- Waste stored for an extended interim period should be locked in a restricted area.

In February, 1993, NRC proposed a new rule that would **prohibit** on-site storage after Jan. 1, 1996, unless a licensee can document that it has exhausted other reasonable waste management options such as attempting to contract for LLRW disposal. The proposed regulation would exempt storage for decay as well as storage to consolidate waste for off-site shipment to an LLRW disposal facility. However, the exemption for collecting or consolidating LLRW for shipment off site would be limited to those licensees that have access to an operating LLRW disposal facility.

In publishing its proposed new regulation, NRC commented that it intends to apply the rule to every license issued for "reactor, material, fuel cycle, and independent spent fuel storage licensees," thereby

amending 10 CFR Parts 30, 40, 50, 70, and 72. Each licensee would not be compelled to make a formal submittal to the NRC to show compliance with the conditions of the proposed rule. Instead, the licensee would need to retain (for at least three years) all relevant documentation of the steps taken to satisfy the requirements of the regulation, for inspection, if necessary.

However, NRC states that it would expect each licensee to make an **annual** request for access to each operating commercial LLRW disposal facility.

The Federal Register announcement of the new rule also noted that this proposed NRC rule would not allow on-site storage of any waste that is not currently authorized under a radioactive materials user's existing license, nor would the proposed rule change existing rules, procedures, guidance, and requirements for on-site storage.

As noted, as of the publication of this Management Plan, the NRC had not taken action to adopt, amend, or delay its proposed new rulemaking.

EPA Regulations on Storage

EPA hazardous waste regulations apply to the storage of mixed waste, as well as to treatment and disposal activities. A detailed review of EPA authority over mixed waste is contained in Chapter 8 of this volume. Major EPA regulations pertaining to mixed waste storage include:

- A prohibition on storing on site any mixed waste identified by the EPA as being restricted from land disposal, unless the storage is only for the purpose of accumulating sufficient quantities of waste to allow treatment or disposal. This restriction prohibits the land disposal of mixed waste unless it has been treated by specific treatment technologies, or it meets specific treatment standards. The lack of available treatment capacity for all types of mixed waste, and the lack of available mixed waste disposal capacity -- two problems identified in Chapter 8 -- have forced generators to store this waste illegally for want of other options.

- Generators of more than 2,200 pounds per month of mixed (and hazardous) waste that store the waste on site for longer than 90 days are required to apply for a Resource Conservation and Recovery Act (RCRA) "Part B" permit, the same permit required for a centralized hazardous waste storage facility.

- Generators who produce between 220 and 2,200 pounds per month of mixed and/or hazardous waste can store the waste for up to 180 days, or 270 days if the waste must be shipped to a storage, treatment, or disposal facility located more than 200 miles away.

State Regulations on Storage

Three state agencies share authority over LLRW. They are DPH, DEP, and the Management Board.

DPH is responsible for radioactive materials and LLRW storage pursuant to three sections of state law:

(1) Massachusetts General Laws c.111, section 5N, designates DPH as the regulatory agency under an Agreement State program, and authorizes DPH to establish regulations for such a program, including storage.

(2) Chapter 111H, section 13, requires DPH to adopt regulations for storage for decay, and

(3) Chapter 111H, section 16, requires DPH to adopt regulations incidental to storage for any storage, treatment, or disposal facilities licensed under that law.

Regulations were adopted by DPH in January, 1994, to meet the requirements of Agreement State status regarding (1) above. Regulations pertaining to storage for decay [(2) above], and centralized storage facilities [(3) above], were adopted by DPH in December, 1993. None of these regulations will apply, however, unless Massachusetts is an Agreement State.

As has been noted, DEP has applied to EPA for RCRA-based authority over mixed waste. Until such authority is granted, DEP's existing hazardous waste regulations control the storage of mixed waste. Chapter 8 contains additional information about DEP authority over mixed waste. Pertinent storage regulations include:

- A requirement that "large quantity" generators (i.e., those that produce over 2,200 pounds per month of mixed or hazardous waste or over 2.2 pounds per month of "acutely hazardous waste") may not store mixed waste on site for more than 90 days without a DEP storage facility license;

- A provision that "small quantity" generators (i.e., more than 220 but less than 2,200 pounds per month or less than 2.2 pounds of acutely hazardous waste per month) may store mixed and hazardous waste on site "at or near each specific point of generation" for an unlimited time period if:

  (a) a key staff person is directly responsible for each specific point of generation; and

  (b) only one container (55 gallons of hazardous or mixed waste or one quart of acutely hazardous waste) is used at any one time.

- A provision that generators of "very small quantities" (i.e., less than 220 pounds of hazardous and mixed waste and no acutely hazardous waste per month) are exempt from all hazardous waste regulations except DEP registration (not licensure).

In addition to the DPH and DEP requirements, the Management Board has authority over LLRW storage policy issues under various provisions of Chapter 111H:

(1) Section 12 authorizes the Management Board to develop, and adopt by regulation, a Management Plan to provide for the "safe and efficient" management of LLRW. Storage policy is related in section 12 requirements for:

  - the classification system developed by the Board (see Chapter 7);

  - the review of storage technologies and practices and the storage-related recommendations in this chapter;

  - the inventory of all radioactive materials users (see Appendix F at the end of this volume);

  - the inventory of storage facilities inside and outside the Commonwealth (see Chapter 15);

  - the required "finding" whether additional storage facility capacity is necessary (see Chapter 15); and

  - the development of "interim and emergency storage plans" if no facility is available to accept Massachusetts-produced LLRW (see Section 12.4 of this chapter).

(2) If a storage, treatment, or disposal facility is sited and licensed in Massachusetts, section 33 of Chapter 111H authorizes the Management Board to institute storage-related policy through the negotiation of a "comprehensive operating contract" with the facility operator.

(3) If such a facility is ready to operate, section 38 authorizes the Management Board to regulate storage incidental to "waste acceptance fees" and "waste acceptance criteria" for the use of the facility.

12.4 Interim and Emergency Storage Plans

As noted above, the Management Board is charged under section 12 of Chapter 111H to effectuate an "Interim and Emergency Storage Plan" "...whenever it appears that no facility is or will be available to accept LLRW generated within the Commonwealth." Such plan may consist of several elements. For example, it could involve contractual agreements for interim storage with facilities located outside Massachusetts. Or, it could include the development of on-site storage plans for every Massachusetts generator. It could also encompass the development of an "interim or emergency storage facility" within the Commonwealth.

In mid-1991, the Management Board began discussions of the components of an Interim and Emergency Storage Plan, even though access to the three disposal sites in Barnwell, South Carolina; Beatty, Nevada; and Hanford, Washington, was supposed to be available to generators in Massachusetts and other states through December, 1992. The 1992 date, as noted in this and other chapters of this Management Plan, is the date authorized by the LLRWPAA when the three "sited" states could cease accepting LLRW from other parts of the country.

The three sited states also believed the federal LLRWPAA authorized them to deny access prior to Dec. 31, 1992. They had interpreted federal law as giving them the authority to:

- approve or reject the "milestone" documents submitted to them and federal agencies by states seeking to comply with the Amendments Act deadlines, and

- continuously evaluate whether a state is in compliance with federal mandates.

By letters dated Jan. 31, 1990 (Nevada), Feb. 6, 1990 (South Carolina), and Feb. 7, 1990 (Washington), the three sited states approved Massachusetts' "Milestone 1990" submission as required by the federal Act,[12] but also indicated their intention to monitor Massachusetts' actions to meet the federal mandates.

In October, 1990, the three sited states formally notified Massachusetts and four other states (Connecticut, New Jersey, Maine, and New York) of their concern that these states could not meet the federal mandate to have a disposal facility available by Jan. 1, 1996. The sited states' communication requested "persuasive evidence" of Massachusetts' ability to achieve this and other federal deadlines.

The Management Board responded on behalf of the Commonwealth, and provided assurances that no LLRW generated in the Commonwealth would be a burden to any other state.

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[12] A complete explanation of the "milestone" requirements of the federal LLRWPAA can be found in Chapter 1 of this volume.

In November, 1990, the warning of loss of access that the three sited states were making to Massachusetts came true for LLRW generators in Michigan, which had also been receiving threats of access denial. This action by the States of Nevada, South Carolina, and Washington, followed a series of events that led them to question Michigan's intent to site a disposal facility in its capacity as host state to the Midwest Compact region.[13] These events included numerous public statements by Michigan's governor against siting within the state; resolutions adopted by the Michigan Legislature expressing opposition to the federal LLRWPAA; suspension of the Michigan siting process;[14] and refusal of the Michigan Legislature to amend its siting criteria to enable a site to be identified.

In January, 1991, the three sited states took a different action regarding Massachusetts. While they notified Governor William F. Weld of their opinion that Massachusetts was out of compliance with federal law, they did not automatically deny access for Massachusetts generators to the disposal sites in Barnwell, Beatty, and Hanford. Instead, they issued another warning, namely that Massachusetts LLRW generators would lose access to those sites if actions were not taken to finance Management Board responsibilities and to site a disposal facility.

Management Board Interim and Emergency Storage Plan

These events led the Management Board to begin preparations for the premature loss of access (prior to Dec. 31, 1992) of Massachusetts LLRW generators from the Nevada, South Carolina, and Washington disposal sites,[15] and the development of an Interim and Emergency Storage Plan.

The Board's Interim and Emergency Storage Plan has three components:

(1) continuous notifications to Massachusetts LLRW generators of possible loss of access, and the need for generators to initiate steps to ensure safe, environmentally sound on-site storage for all their LLRW;

(2) procedures to ensure that Massachusetts generators, who may wish to ship their LLRW out

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[13] The Michigan LLRW generators' organization, MICHRAD, filed suit against the three sited states, challenging their action to deny access. In June, 1991, the U.S. District Court for the Western District of Michigan entered partial summary judgement in favor of MICHRAD, enjoining officials of Nevada, South Carolina, and Washington from denying access to their disposal sites. In July, 1991, the district court denied the three sited states' motion for a stay of judgment and permanent injunction, pending appeal. In September, 1991, the U.S. Court of Appeals for the Sixth Circuit granted the sited states' motions, thus allowing the denial of access action to continue. The three sited states subsequently won the appeal.

[14] Michigan had initiated a statewide screening program to identify potential sites for the facility it was supposed to host for the Midwest Compact, representing the states of Indiana, Iowa, Minnesota, Missouri, Ohio, and Wisconsin, in addition to Michigan. In 1989, three candidate areas were identified that contained such possible sites. However, by May, 1990, all three candidate areas were eliminated from further consideration.

[15] Massachusetts generators continue to have access to a disposal site in Clive, Utah, which is available for the disposal of certain high-volume, low activity LLRW, as well as NARM waste (Naturally-occurring and Accelerator-produced Radioactive Material), that was not accepted by the disposal sites in South Carolina, Nevada, and Washington (and is not considered in the definition of LLRW in federal law). Until 1992, when over 60,000 cubic feet of high-volume, low activity soils were shipped from Massachusetts to Utah (as the result of certain decommissioning events in the Commonwealth), the Utah site was not utilized to any great degree by Massachusetts generators.

of state for treatment, and then have it returned to them for on-site storage, would not be hampered by requirements of other states pertaining to the processing of LLRW and its return to Massachusetts; and

(3) procedures to protect the Commonwealth's interests regarding denial of access events; and to ensure a coordinated state agency response to such events, with involvement of LLRW generators and the public.

The Board is fulfilling number (1), above, through periodic communications with Massachusetts LLRW generators on the status of access to out-of-state disposal sites. That activity is an on-going Board effort.

To accomplish number (2), above, on May 15, 1991, the Management Board established a policy regarding the re-entry of LLRW into the Commonwealth after shipment out of state. This policy was developed out of a concern that LLRW treatment companies would seek protections to avoid the costs and ensuing liability of having to take ownership responsibility for waste that has no disposal destination. Because most LLRW treatment occurs out of state, the Board wanted to ensure that generators evaluate their options for having LLRW treated off-site, prior to on-site storage.

At that time, the State of Tennessee was the only state that had an official policy restricting the actions of its processors regarding out-of-state waste. Tennessee hosts several processing firms, including the nation's leading LLRW volume reduction companies: Scientific Ecology Group, Inc. and Quadrex Recycling Center. Tennessee had to ensure that waste entering its state for treatment would be sent back to the state of origination, if access were denied to the disposal sites in Barnwell, Beatty, and Hanford.

Tennessee's regulations allow processors to treat LLRW from generators that have no available disposal options, as long as the generators gain written assurances from their own state's Governor, their state radiation control program, and a compact official,[16] indicating that the waste may be returned to the generator.

This Tennessee requirement was utilized by Michigan LLRW generators after their access to the sited states' disposal locations was denied in 1990.

Objectives of Out-of-State Treatment

The Management Board identified the following goals of a policy encouraging the out-of-state treatment of LLRW:

- Such a policy allows an orderly flow of radioactive waste processing.
- Treatment results in more stable waste forms, which reduce potential public health and environmental threats during later disposal.
- It is safer to have waste stored on site that has been treated than to have waste stored on site that has undergone no treatment.

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[16] States that are members of regional "compacts" for the management of their LLRW must comply with rules of the Compact Commission, in addition to state and federal regulations. The Tennessee regulation, therefore, asks for written assurances from the Compact Commission as well as from the state. Massachusetts Is not a member of an LLRW regional compact.

- Financial costs to the Commonwealth are minimal. Routine inspection while waste is in transit to out-of-state treatment sites is already the responsibility of the State Police; no extra personnel should be necessary. The inspection of LLRW packages on the premises of radioactive materials licensees, which produce and store LLRW as a by-product of their operations, is currently the responsibility of the NRC. When Massachusetts becomes an "Agreement State" and regulatory authority for licensing and inspection is transferred to DPH, waste package inspections will be funded through licensing fees.

- The treatment of LLRW to "render such waste safer for management, amenable for recovery, convertible to another usable material or reduced in volume" [Chapter 111H, section 1] is consistent with the requirement that every LLRW generator minimize sources and volumes of LLRW produced.

Statutory Authority for Board's Policy

Chapter 111H gives the Management Board the enabling authority to manage LLRW in the Commonwealth. That authority allows the Board to set standards for waste re-entering Massachusetts as long as such standards do not restrict the interstate commerce of LLRW. The principal effect of the Board's policy is to deny re-entry to LLRW that does not satisfy the waste acceptance criteria imposed pursuant to the generator's contract with waste processors. Therefore, the impact on interstate commerce is minimal. Such limited exercises of the State's policy power have been upheld in court in the face of constitutional challenges.

The Management Board policy regarding re-admittance of LLRW into Massachusetts after shipment to out-of-state processors recognizes the importance of protecting the Commonwealth from the same issues that concern LLRW processors: title and liability for abandoned waste. While the policy is designed to encourage the use of out-of-state waste treatment, it also makes clear the state's present obligations concerning possession, storage, and disposal. Once Massachusetts has resolved its long-term disposal capacity needs, this policy will be re-examined for any necessary modifications.

The policy emphasizes that waste may return from out-of-state processing facilities if the LLRW generator has fulfilled certain conditions, including an agreement to accept waste back within the terms of its license.

The re-entry policy, approved by the Management Board on May 15, 1991, appears in Figure 12-A.

Procedures for Coordinated State Agency Response

In order to fulfill the third component of its Interim and Emergency Storage Plan (see (3), above), in June, 1991, the Board began discussions of a draft "Coordinated State Agency Response," to identify a set of procedures for apprising and involving other interested state agencies, LLRW generators, and the public, of actions involving loss-of-access events. This portion of the plan includes:

- the offices of the Governor and Lt. Governor;

- the Attorney General's office;

- the Management Board;

- DPH;

- the Department of Labor and Industries (DLI);
- LLRW generators; and
- the public.

Figure 12-A
Massachusetts Re-Entry Policy for LLRW

"The Low-Level Radioactive Waste Management Board encourages Massachusetts generators to send their low-level radioactive waste to processors for treatment. This policy is consistent with the provisions of M.G.L. c.111H, Section 13, which requires Massachusetts generators to implement "all appropriate" methods for minimizing waste volumes.

"Every effort should be made to ensure that waste that is shipped out of state for treatment will thereafter be accepted for disposal without having to be returned to its generator. However, in the event that Massachusetts low-level radioactive waste generators lose access to the three existing disposal sites in Nevada, South Carolina, and Washington, the Board recognizes that out-of-state processors may require the Commonwealth's assurances that waste shall be permitted to re-enter the Commonwealth to be returned to its generator for storage.

"Such assurances will be provided, upon request, with respect to all shipments of low-level radioactive waste for treatment out of state that satisfy the following four conditions:

(1) The Board has been given prior notification of the waste shipment to be returned, indicating the chemical composition, activity and volume of the waste, the shipping destination and carrier,

(2) The generator is authorized to, and has agreed to accept the waste back within the terms of its license;

(3) The generator has executed a contract for the treatment or processing of the waste; and

(4) The waste satisfies any and all waste acceptance criteria imposed pursuant to such contract.

"By providing such assurances, the Commonwealth does not agree to permit re-entry of the waste for purposes other than its return to the generator. In particular, the Commonwealth cannot and does not agree to accept possession of the waste or otherwise provide for its storage or disposal. Nor does the Commonwealth accept responsibility for any losses, claims or costs incurred in connection with, or as a result of the re-entry of the waste."

Adopted May 15, 1991

Source: Massachusetts Low-Level Radioactive Waste Management Board.

Governor and Lt. Governor. The offices of the Governor and Lt. Governor are to receive background materials and periodic updates prior to, and after, any loss-of-access decision affecting Massachusetts' LLRW generators' ability to utilize disposal. Materials will include status reports of actions by various affected state agencies and interested groups, such as LLRW generators.

Attorney General's office. The Attorney General's office is to receive background materials pertinent to loss-of-access with special emphasis on relevant legal issues. If a legal challenge to a loss-of-access action is undertaken by one or more Massachusetts generators,[17] the Management Board will arrange a meeting between the Attorney General's staff, the litigating generator's counsel, and Management Board counsel to discuss the Commonwealth's interests in such a court challenge. If such a suit is initiated, the Management Board will provide periodic updates to the Attorney General's office on the status of the

[17] The Management Board legal counsel recommended in 1991 that the Commonwealth not initiate legal action on premature loss-of-access, but instead leave court challenges to the generating community. No official decision was made by the Board on this point, however.

litigation.

If such a suit is filed, the Attorney General's office is to discuss with the Board's counsel the advisability of joining the legal action.

Management Board. For its part of the coordinated state agency response to loss-of-access action, the Management Board identified a number of tasks to be included in the Interim and Emergency Storage Plan. The Board will:

- Ensure that the offices of the Governor, Lt. Governor, Secretary of Environmental Affairs, Attorney General, DPH, and DLI receive background materials and updates relative to loss-of-access activities. Management Board newsletters that are sent to generators, citizens groups, and other interested parties will provide periodic updates on loss-of-access issues.

- Review LLRW generator information compiled from the most recent annual survey, to ascertain each generator's ability to store waste on site.[18] If necessary, the Board will assist generators to ensure that on-site storage preparations and activities are conducted in a manner that protects the public health, safety, and the environment.

- Emphasize to every LLRW generator the need for source reduction/elimination, LLRW minimization, and the use of storage for decay to the greatest extent possible. The Board will send every generator a copy of the Board's recommendations for such a program, and DPH's regulations creating such a program (once the Commonwealth has become an Agreement State). The Management Board will coordinate its efforts with the DPH Radiation Control Program to provide technical assistance on minimization strategies.

- Assist generators, when requested, to gain NRC license amendments regarding the quantities of LLRW that may be stored on-site for an extended period of time.

- Provide all LLRW generators with information on the Board's policy regarding the re-entry of LLRW into the Commonwealth after shipment to out-of-state processors.

- Periodically update all radioactive materials licensees and all Massachusetts state and federal legislators about the State's loss-of-access activities.

- Ensure that the Board's counsel shares with counsel for the Governor, the Secretary of the Executive Office of Environmental Affairs, and the Attorney General's staff all legal analysis pertaining to loss of access.

- If litigation is pursued by the generating community, evaluate recommendations of counsel, the Governor's legal counsel, and the Attorney General's office concerning any Commonwealth legal action.

In addition, the Management Board recommends that the Governor's office and DPH refer any inquiries to the Board regarding the re-entry into the Commonwealth of waste from out-of-state

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[18] To fulfill the requirements of this task, the Management Board contracted with a private consulting firm in 1993 to conduct a special "on-site storage" survey of every LLRW generator in Massachusetts, complete with site visits, to verify each generator's preparations for on-site storage. A final report of the consultant's work is to be published in January or February, 1994.

processors.[19]

DPH. The DPH Radiation Control Program will receive background materials and update reports from the Management Board relative to loss-of-access.

If loss of access occurs, the Radiation Control Program, in cooperation with the NRC, is to coordinate with the Board to assist LLRW generators achieve greater source and volume minimization and elimination, and storage for decay.

DLI. The DLI is to refer to the Management Board all inquiries regarding any loss-of-access actions.

LLRW generators. LLRW generators are to receive periodic updates describing the Commonwealth's activities regarding loss of access. For their part, LLRW generators are to provide accurate and complete data on their current and anticipated generation of LLRW, and their needs for on-site waste storage and license modifications to accomplish such storage.

In addition, individual LLRW generators or generator associations that may decide to initiate a legal challenge on any loss-of-access decision are to communicate their plans to the Management Board so that the Board can update all involved state agencies, in order to evaluate potential courses of legal action on behalf of the Commonwealth.

The public. The Massachusetts Congressional delegation, state legislators, and members of the public will receive periodic updates from the Management Board, describing the Commonwealth's activities regarding loss of access. The public will continue to have the opportunity to utilize the formal and informal Public Comment periods of each Management Board meeting, to discuss loss of access issues with the Board.

The Management Board has yet to finalize its "Coordinated State Agency Response" portion of the Interim and Emergency Storage Plan, due to its success in arranging for continued access at the Barnwell, South Carolina disposal site, through June, 1994. As the end of the contract extension period approaches, the Board is reviewing its recommendations for ensuring a coordinated state agency effort on this issue.

Interim and Emergency Centralized Storage Facility

In considering the components of its Interim and Emergency Storage Plan, the Management Board also discussed the concept of developing an interim and emergency storage facility to provide a centralized, in-state location for interim LLRW storage, if access to the Barnwell, South Carolina, LLRW disposal site ceases to be available. In January, 1991, and again in September, 1991, the Board concluded that no need existed at the time to site, develop, and operate such a facility for LLRW produced by "small-volume" LLRW generators, who were the only ones identified from the Board's annual survey that might experience minor problems with storage.

Data compiled from the Board's 1989 and 1990 surveys indicated that all "large-volume" generators were preparing for on-site storage, and anticipated no significant difficulties with their plans. The survey data

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[19] The Management Board, on behalf of the Commonwealth, signed an "Interregional Access Agreement for Waste Management" on Jan. 13, 1993. The agreement, which has been entered into by most of the states and regional compacts involved in LLRW disposal, is designed to facilitate access to treatment facilities for generators, and to assure states where such facilities operate that they will not be responsible for disposing of LLRW generated outside their borders. This assurance is provided by the signatories agreeing not to impede the return of LLRW that was exported for treatment.

also revealed that none of the LLRW generators who produced small quantities of LLRW predicted they would have serious space problems in planning for on-site storage after 1992, although three small-volume generators said they might experience some problems. As a result of the survey responses, the Board felt there was no need to site a centralized interim and emergency storage facility, because its staff could provide the necessary technical assistance to resolve any minor difficulties involving storage that the small-volume generators may experience.

Therefore, the Management Board's Interim and Emergency Storage Plan does not include a provision for centralized storage. If the Board were to decide to establish such an interim and emergency storage facility, Chapter 111H, section 12, would allow the Board to omit some of the siting steps required in other sections of the Act for the siting of non-emergency, long-term, centralized LLRW storage, treatment, and disposal facilities. Omitted from the steps identified in Chapter 1 of this volume are:

Operator selection. The operator for any storage, treatment, and disposal facility (other than an interim and emergency storage facility) is selected by the Community Supervisory Committee of the superior site community, as determined by the Management Board after a statewide screening process intended to identify the best "candidate" sites, and, finally, one or more "superior" facility sites. However, in the case of an interim or emergency storage facility, section 12 of Chapter 111H authorizes the Management Board (or its designee) to apply for a license for such a facility without being designated as an "operator" pursuant to section 16 of the Act. It also authorizes the Board to construct and operate a facility to accept LLRW for interim or emergency storage. These provisions thereby substitute the requirements for:

- operator selection that would result from superior site selection in section 20;
- the CSC choosing the facility operator pursuant to sections 21 and 27;
- the Board's issuance of a Request for Proposals to identify companies interested in developing, operating, and closing an LLRW facility pursuant to section 22; and
- the execution of a development contract pursuant to section 28.

Section 12 of Chapter 111H does require, however, that no interim or emergency storage facility may be constructed unless DPH has conducted an environmental monitoring program at the storage site, as required in section 36 of the Act, and has produced representative baseline data about the site in order to provide early warning of the magnitude and extent of any radionuclide migration, and to provide reliable environmental data throughout the various phases of facility development, operation, closure, and institutional control.

Because an interim and emergency storage facility would be evaluated for licensure on exactly the same criteria in the DPH licensing regulations as any other facility, an interim or emergency storage facility would have to satisfy the same environmental standards as a long-term facility.

The provisions for interim and emergency storage in section 12 also require that the Management Board must specify "in its Interim and Emergency Storage Plans" the maximum length of time during which such a facility would operate. As noted, the Board's Interim and Emergency Storage Plan does not include any provision for such a storage facility, or any duration of its operation.

12.5 Existing Storage Activities in Massachusetts

Short-term, interim, and long-term storage, (as well as storage for decay) can occur at the site where

waste is produced, at a location where a processor treats the waste, or at a disposal site while awaiting final emplacement in the facility. It can also occur at a centralized facility built just for the purposes of providing interim storage prior to disposal, or for allowing long-term storage.

Short term storage, interim storage, and storage for decay activities presently occur at about 60% of the 450 licensed users of radioactive materials in the Commonwealth.[20] These activities are permitted under the NRC licenses held by all users, and are an integral part of the management of radioactive materials and LLRW.

In addition, storage occurs on sites where LLRW that was buried years ago (under different regulatory requirements) is now being removed through site decommissioning and remediation. In some of the site remediations, LLRW and/or mixed waste have been packaged for on-site storage while other remediation work is underway. Such is the case at the Ventron site in Beverly, Massachusetts, where over 6,200 cubic feet of contaminated soil, concrete, metal, and rubble are in storage while the remediation efforts are completed.[21]

The issue of whether or not stored waste will remain on site, once the decommissioning of an old burial site is completed, is of concern to the Management Board. Site owners and other responsible parties are eager to relinquish their legal responsibilities at the sites, and are not likely to want to maintain the financial responsibility for monitoring and maintaining waste in storage. The federal and state regulatory agencies overseeing old burial site decommissionings and remediations (DOE, NRC, EPA, DEP) are also anxious to "close the books" on each site cleanup effort. To date, these agencies have not liberated the responsible parties from their full obligations at the site. According to the NRC, responsible parties will be required to make arrangements for storage somewhere that is agreed upon by the agencies supervising the remediations. Whether that will be on site, or elsewhere, is not known at this time.

There are no licensed storage "facilities" in Massachusetts, as defined in Chapter 111H for the centralized storage of LLRW, for either "interim" or "long-term" time periods. That is because the siting process in Chapter 111H has not been utilized to identify land for storage, treatment, or disposal activities.

However, there are parcels of land in Massachusetts that are used by individual radioactive materials licensees and groups of licensees for the interim storage of LLRW prior to its shipment for disposal. The case study of a shipment of tritium-contaminated waste by E.I. Du Pont De Nemours and Company detailed in Appendix 9A of Chapter 9 describes how Du Pont's Boston headquarters sends waste to Billerica for storage prior to shipping it for disposal. In addition to the Du Pont storage example, other instances' of existing NRC-licensed on-site storage activities include all of the state's major LLRW generators: Nuclear Metals in West Concord, Boston Edison in Plymouth, Yankee Electric in Rowe, Du Pont in Boston and Du Pont Merck Pharmaceuticals in Billerica.

One unique arrangement for "group" storage of waste is conducted by Harvard University for its 15 affiliated institutions that provide research facilities for Harvard affiliated programs, and whose research staffs hold Harvard appointments. Waste is stored for decay at the University's Southboro campus. Because of their affiliation with Harvard, these institutions have access to the storage (and treatment) services of Harvard. In addition, all of these licensees has authority to store on their own sites under the provisions of

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[20] The remaining users are licensed only to use "sealed sources" which do not produce any LLRW unless they are damaged. When a sealed source has lost its potency, it is sent back to the manufacturer, which decides whether it can be recycled or requires disposal.

[21] A discussion of decommissioning and remediation activities can be found in Chapter 14 of this volume.

their NRC licenses.[22]

The Harvard University program is an unusual storage situation in Massachusetts, in that so many institutions store their waste at the site in Southboro. While a few other Massachusetts licenses have combined storage arrangements (such as Massachusetts Institute of Technology and Boston University), most storage occurs at the site of generation, and is either storage for decay or storage prior to shipment for treatment or disposal. In addition, some generators have contracts with brokers and processors who store waste prior to treatment or disposal.

These storage activities all existed prior to the adoption of the State's LLRW management law in 1987. A provision accompanying Chapter 111H when it was signed into law exempts these licensees from the law's complex requirements of locating sites for their future storage activities. However, the language also authorizes the Management Board to evaluate, on a case-by-case basis, whether any amendments to previous NRC licenses are "consistent" with this Management Plan.[23] The provision states:

> "Nothing in this act shall prohibit the Department of Public Health from issuing a renewal license to any person lawfully holding a license to accept waste for treatment, storage or disposal as of the effective date of this act and any such person may apply to said department for an amendment of the terms and conditions of such license if the application for such amendment has been determined by the Low-Level Radioactive Waste Management Board to be consistent with the Management Plan adopted pursuant to section 12 of Chapter 111H of the General Laws." [St. 1987, c.549, section 8]

12.6 Analysis of LLRW Storage Technologies and Practices

The analysis of current and developing LLRW storage technologies and practices, required by section 12(b)(2) of Chapter 111H, must also include an evaluation of the following:

(1) the potential public health, safety, and environmental impacts of storage technologies and practices;

(2) their climatic, geologic, hydrogeologic, or other requirements;

(3) their suitability for the LLRW managed within Massachusetts;

(4) their cost-effectiveness;

(5) recommendations for regulatory or other actions to improve the safety or efficiency of storage

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[22] The 15 Harvard affiliated institutions include: Massachusetts General Hospital, Brigham and Women's Hospital, Beth Israel Hospital, Children's Hospital, Dana Farber Cancer Institute, McLean Hospital, Forsyth Dental Center, Eunice Kennedy Shriver Center, Faulkner Hospital, The Center for Blood Research, Joslin Diabetes Center, Spaulding Rehabilitation Hospital, Boston Biomedical Research Institute, Eye Research Institute, and Jewish Rehabilitation Hospital.

[23] Such an evaluation would occur only after Massachusetts becomes an Agreement State and DPH assumes regulatory authority for the licensure of most radioactive materials users in the Commonwealth (excepting the utility plants, federal government installations, and university research reactors) and any facilities sited, built, and operated under the provisions of Chapter 111H.

technologies and practices, and

(6) recommendations for regulatory or other actions to ensure that property values are maintained in the vicinity of any storage facility.

The following section includes an analysis of the first five evaluation areas listed above. The subject of item (6), above, is contained in Chapter 17.

(1) Potential Health, Safety and Environmental Impacts

There are potential adverse impacts on health, safety, and the environment from LLRW storage, especially long-term on-site storage. The severity of such on-site storage safety hazards is dependent upon the type of waste in storage, radiation levels of the LLRW, the amount and concentration of radionuclides in the stored waste, how readily they may enter the environment, and to some extent the length of time the waste remains in storage. These impacts include the potentials for:

- operating problems to result in the release of radiation due to inexperience in managing greater quantities of waste for extended periods of time;
- greater exposure of workers to radiation due to the increased numbers of curies in storage for extended periods of time, the potential lack of proper shielding to reduce radiation doses received by workers, and the need for periodic inspections to ensure package integrity;
- fires, explosions, or other incidents due to chemical reactions as a result of inexperience in handling LLRW that had previously been shipped to treatment and disposal sites;
- spills if liquid LLRW is held in storage and requires greater handling prior to disposal;
- corrosion or loss of package integrity of storage containers if LLRW is not properly treated and packaged for extended storage;
- unsuitable storage locations or unsafe storage design to be used by some LLRW generators, which could allow radioactive wastes to enter the environment during extended storage periods; and
- health, safety, or environmental damage during the decontamination and decommissioning of areas used for interim storage.

While LLRW can be safely stored both for short and long periods, such storage may be safest and most protective of the public health and the environment in a centralized storage facility that was sited, designed, and operated by individuals trained for this purpose alone. If several hundred producers of LLRW in the Commonwealth were to each hold their waste in storage, especially larger quantities to be stored for longer time periods, the potential for an accident to occur would undoubtedly increase (although the severity of any individual accident would likely be less than an accident involving larger quantities of waste at a centralized storage facility). This concern was expressed by the former President of the Health Physics Society of the United States in an article in an August, 1990, Health Physics Society publication:

> "On-site storage by the thousands of licensees in the states that may lose access to the existing facilities could create problems never before encountered in the use of radioactive materials. The accumulation of large volumes of low-level radioactive waste in hospitals, universities, and in research and industrial corporations in our major cities presents obvious problems. There may conceivably be fires involving such materials, spills, loss of control,

"On-site storage by the thousands of licensees in the states that may lose access to the existing facilities could create problems never before encountered in the use of radioactive materials. The accumulation of large volumes of low-level radioactive waste in hospitals, universities, and in research and industrial corporations in our major cities presents obvious problems. There may conceivably be fires involving such materials, spills, loss of control, even orphan waste when marginal businesses fail. These are precisely the potential problems the NRC has traditionally regulated against by minimizing waste storage times and volumes. In addition to the unnecessary risks associated with the long-term storage, there is also the added work risk due to the need for multiple handling and repackaging prior to final disposal."[24]

The potential for environmental problems due to LLRW storage can be minimized through the use of appropriate waste containers coupled with proper storage facility design, location, construction, and operation. To a large extent, these factors are affected by each waste generator's ability to design, construct, monitor, and maintain storage facilities, and to fulfill regulatory quality assurance requirements. For example, protective coatings on carbon steel waste containers (e.g., zinc-coating to "galvanize" drums, or organic coatings) can reduce corrosion from both the LLRW inside the container and the atmospheric conditions outside.

Environmental problems can also be diminished through the government's ability to provide for inspection and enforcement. However, if available inspectors are fewer than the number necessary to ensure routine inspection, the State's ability to protect the environment from any storage-related problems is hampered. Likewise, sufficient inspection personnel (a requirement of all Agreement State programs) can ensure proper operation and maintenance of storage facilities by LLRW generators.

There are positive aspects of storage technologies and practices, that enhance environmental protection. These include the facts that:

- the waste is easily retrievable if a problem arises;
- the storage period is not extensive, and the integrity of waste containers should therefore not be a problem under proper handling and management conditions; and
- while waste is in storage, new treatment procedures may be developed that can enable the waste to be recycled for reuse; or can further reduce or eliminate the chemical properties of certain wastes, thereby resulting in less waste requiring disposal.

(2) Climatic, Geologic, Hydrogeologic, or other Requirements

Environmental factors including climatic, geologic, and hydrogeologic conditions affect different types of storage "technologies" in different ways. Climatic, geologic, or hydrogeologic conditions should not be major considerations for waste stored in accordance with all applicable requirements in locations within buildings or areas established and monitored for storage.

However, these may be appropriate considerations for the outside storage of waste in unshielded sheds or atop concrete slabs. In such situations, the potential exists for a waste container to crack, corrode, or lose its integrity; and for the waste form to degrade, potentially increasing the chance that some waste may enter the air, ground or water. In addition, climatic changes such as freezing, thawing, and high

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[24] Masse, F.X. "Implications of the Federal Low Level Radioactive Waste Policy." Newsletter. Health Physics Society, McLean, VA, August, 1990.

fluctuations (in unheated facilities in areas with cold winters) and corrosive atmospheres (e.g., industrial and marine atmospheres, as well as acid deposition)."[25] Additionally, stored waste packages will receive more handling, and therefore must retain their package integrity or require repackaging.

Because of the types of LLRW produced by nuclear-powered electric generating plants (i.e., higher radioactivity wastes), any storage proposed by a utility company requires an environmental analysis "to determine if the proposed activity will significantly affect the quality of the environment." [Generic Letter 81-38]

Climatic, geologic, hydrogeologic, and other environmental conditions would affect the siting and development of a centralized storage facility. If a storage facility were to be sited in the Commonwealth to serve all or a group of LLRW generators, it would be subject to certain requirements pertaining to environmental impacts. These include:

- a review of climatic, geologic, hydrogeologic, and other environmental impacts during the identification of a suitable site;

- a review of these environmental criteria during detailed site characterization by the Management Board and the potential site community;

- an environmental review pursuant to Massachusetts Environmental Policy Act (MEPA) requirements by the Executive Office of Environmental Affairs [Chapter 30, section 62], prior to licensure by DPH; and

- the facility design and performance specifications of any draft license issued by DPH.

(3) Suitability of Storage Technologies for Massachusetts LLRW

The issue of the suitability of storage technologies and procedures for managing LLRW in the Commonwealth is dependent upon a number of variables and the types of storage under consideration. These include:

- the availability of access to out-of-state storage and disposal facilities;

- the inventory of radionuclides and waste forms for storage;

- the ability to monitor all storage locations;

- the capital and operating costs of various storage technologies and practices and their impacts on the jobs and revenues to the Commonwealth that result from radioactive materials use;

- the environmental impacts of storage;

- the public health and safety considerations of storage; and

- the political and social implications of storage policy.

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[25] Siskind, B. "Extended Storage of Low-Level Radioactive Waste: Potential Problem Areas." NUREG/CR-3062, Proceedings of the Seventh Annual Participants' Information Meeting, CONF-8509121, EG&G Idaho, Inc., Idaho Falls, ID, February, 1986.

Most LLRW in Massachusetts currently being packaged for disposal in Massachusetts is suitable for on-site storage designed with the appropriate safeguards. However, waste that tends to degrade rapidly, such as biological waste and animal carcasses, poses some problems for interim and long-term storage. It may require effective stabilization prior to placement in storage.

Debates about the suitability of interim and long-term storage in Massachusetts may be superfluous in light of pending actions regarding the site at Barnwell, South Carolina. Generators from the states (including Massachusetts) that have contracts to use that site only until June 30, 1994, will thereafter have no alternative but to employ interim, on-site storage. The alternative to interim storage under such a circumstance is elimination of the activities in the Commonwealth that generate LLRW as a by-product, including cancer detection and treatment, medical research, manufacturing, academic research, and electric power generation. Consequently, an evaluation of whether or not interim storage is the most favorable short-term solution to LLRW management may not be necessary in light of national actions.

However, the suitability of the various <u>types</u> of storage can be assessed.

<u>Storage for decay</u>. Storage for decay is a practice that results in the reduction of radioactive quantities. Storage for decay is a common procedure used by over two-thirds of the radioactive materials users in Massachusetts. Storage for decay <u>should</u> be encouraged because:

- it almost always occurs at the site of generation, involving no waste transportation, and minimizes the potential for accidents that could expose the public to radiation;

- it is a relatively short period for many radionuclides that decay to background levels in hours, days, weeks, or months;

- formerly radioactive components in LLRW may be able to be reused or disposed of as conventional solid waste, without harm to the public or the environment; and

- it is the most cost-effective treatment process for both the LLRW generator and the Commonwealth.

<u>Interim storage</u>. Interim storage, both on-site and centralized, is a function of the factors discussed earlier in this chapter. With the proper design features built into an interim storage system, combined with the requisite regulatory personnel to carry out inspection and enforcement, this practice can augment the protection of radiation workers from excessive exposure; prevent negative environmental conditions (weather, heat, cold, etc.) from affecting the waste or its containers; and cause no adverse impact on the public health or the environment.

<u>Long-term storage</u>. Concerns about the ability of individual LLRW generators to store certain wastes on site for longer than five years, as well as the various other factors discussed in this section, raise questions about the suitability of on-site long-term storage. However, <u>off-site</u>, centralized storage can be sited, designed, constructed, operated, closed, and decommissioned in a desirable manner that protects the health, environmental, and economic interests of the Commonwealth and its radioactive materials licensees, and can serve as a suitable management option.

Centralized interim or long-term storage should be weighed against disposal, evaluating such factors as the environmental suitability and economics of both options. Unless the NRC changes its current policy limiting storage to five years, long-term storage cannot be considered an alternative to disposal unless the half-lives of the radionuclides in the waste reduce it to background radiation levels. Moreover, since every state is required by federal mandate to provide disposal (either in-state or out), all the factors cited in this section would require evaluation twice -- once for a storage facility, and once for disposal.

However, because there are several new LLRW disposal facilities under development around the country, the possibility exists that the states advancing those facilities may accept Massachusetts-produced LLRW. As of December, 1993, all "siting" states were publicly refusing to take Massachusetts LLRW. These positions could change in the future, however. If, for example, an agreement were reached that an out-of-state facility would at some time accept Massachusetts LLRW for disposal, then siting a centralized interim or long-term storage facility in Massachusetts might become a suitable management decision.[26]

(4) Cost-Effectiveness

The requirement cited in section 12 of Chapter 111H for an evaluation of "cost-effectiveness" pertains to the cost-effectiveness of storage technologies and practices from the perspective of the Commonwealth. In evaluating the costs of various technologies, not only the direct costs to the Commonwealth of these approaches must be considered, but also the indirect ones.

Decisions made by Massachusetts might affect the costs of storage to LLRW generators, which could arguably not be "effective" expenditures on their part. These costs could potentially drive their businesses, medical research, and other "user" activities out of the Commonwealth, thereby adversely affecting the Massachusetts economy. Costs for storage could result in increased costs for products and services, and put Massachusetts radioactive materials licensees at an economic disadvantage with respect to their out-of-state competition. This could affect the Commonwealth in terms of jobs and revenues.

The most cost-effective storage is that which reduces the total waste management costs (i.e., a combination of storage, treatment, and disposal) for both LLRW generators and the Commonwealth.

For most LLRW generators, LLRW storage is cost-effective when compared to the costs of re-locating their radioactive materials-related activities to other states where disposal sites are available. However, storage is not "inexpensive" either to the waste producers or to the Commonwealth. Because storage is an "add-on" to the costs of disposal, and disposal will still be required for all waste containing radionuclides that will take longer than the permissible storage period to decay to background levels, the cost-effectiveness of storage needs to be evaluated in the context of available disposal options.

Many factors control the costs of interim and long-term storage. These include:

- the storage location (i.e., "on" or "off" site);
- the type of storage facility (i.e., centralized [for a group of generators] or individual);
- the design of a storage facility;
- the amount of waste treatment required prior to storage;
- the types of radionuclides and their concentrations, which could require greater shielding to

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[26] As noted earlier in this chapter, the NRC has released a proposed new regulation that would prohibit on-site storage (except storage for decay) after Jan. 1, 1996, unless a licensee could document that all reasonable efforts were made to contract for LLRW disposal. The NRC's Federal Register announcement of the proposed rule in February, 1993, did not answer the question of whether the five-year (maximum) on-site storage rule would apply **beyond** Jan. 1, 1996. For example, if Massachusetts LLRW generators retain access to the Barnwell, South Carolina, disposal site through June, 1994, will they be able to store LLRW on site for five years starting in July, 1994 (i.e., through July, 1999)? Or, will they be authorized to store on site for only 18 months (i.e., from July, 1994, through December, 1995)?

protect workers from radiation doses; and

- the potential need to repackage stored waste in order to comply with future storage or disposal requirements.

An analysis to evaluate the cost-effectiveness of on-site storage would differ for each radioactive materials user in Massachusetts. For most of the approximately 450 organizations and institutions licensed to use radioactive materials in the Commonwealth, the costs may involve:

- expanding their present storage space into an unused laboratory or other available space, and modifying that space to provide isolation for the stored waste;
- purchasing containers suitable for storing waste;
- enhancing the LLRW generators' occupational safety and training programs;
- supplementing personnel time to process, inspect, and maintain the stored waste;
- providing on-site treatment, or paying for treatment and transportation to and from an off-site treatment facility;
- paying for additional insurance coverage;
- seeking license amendments to store larger quantities of radionuclides on site;
- providing for decontamination and decommissioning of the storage area; and
- maintaining community acceptance and involvement in the process.

The largest LLRW producers in Massachusetts, on average, by volume and curie content (e.g., Boston Edison, Yankee Atomic Electric Company, and E.I. Du Pont De Nemours), all currently have storage facilities to handle their existing practices that generate LLRW. If they need to provide additional storage, their added costs may cover the following:

- identifying land area at their sites suitable for the construction of storage buildings;
- preparing safety analysis reports and the environmental studies required by NRC, EPA and DEP (i.e., permitting and licensing for storage of mixed waste);
- designing storage facilities to ensure protection of the waste containers from inclement weather;
- designing storage facilities to reduce worker exposure to radiation;
- obtaining any local permits that may be required;
- constructing storage buildings;
- purchasing High Integrity Containers (approximately $15,000 each) for storage of certain types of LLRW;
- installing electronic surveillance and monitoring equipment in and around storage buildings; and

- providing additional worker training to all employees who will be responsible for day-to-day storage activities.

Interim storage may result in lower costs to the generator if storage provides enough incentive to minimize further the amount of waste generated in the first place.

Off-Site Storage

The costs of off site storage depend upon the type of off-site storage employed. If storage is conducted by a broker, costs to radioactive materials users would include:

- packaging waste for storage and shipment;

- the possible need to repackage waste for shipment or disposal if requirements change during the storage period;

- shipping costs;

- liability insurance; and

- fees charged by the broker.

The Commonwealth's expenses would be essentially the same as that for on-site storage, if the brokers were located in Massachusetts. Storage by out-of-state brokers, however, would have little financial impact on the State.

If storage occurs off site at a centralized storage facility that must be sited, developed, and operated within the Commonwealth, costs would include the items listed above as well as expenses for facility siting, licensing, development, operation, closure, decontamination, and decommissioning.

State's Costs

The State's costs of storage will vary significantly, depending upon the type of storage practice chosen. If storage occurs on site where the waste is produced, the radioactive materials licensee will finance most of the related expenses. The Commonwealth's costs, though not negligible, will be modest, including such activities as:

- Increased inspection and enforcement by the DPH after Massachusetts becomes an Agreement State;

- additional personnel and related costs to meet NRC's requirements for an Agreement State program;

- costs to license all generators' storage activities; and

- costs to provide technical assistance.

DPH anticipates that its licensing fees will cover all of the operating costs of an Agreement State program, including inspection and enforcement.

In contrast, a major cost to the Commonwealth will result if the State decides to site, build, and

operate a centralized storage facility. As noted in Section 12.4 of this chapter, the Management Board voted in January, 1991, and again in September, 1991, not to proceed at those times with the development of an interim or emergency storage facility for certain "small-volume LLRW generators" that may not be economically capable of providing such storage on site. However, the possibility exists that, at a later date, the Management Board could decide to establish a centralized storage facility (for some or all generators), depending upon factors relating to long-term disposal decisions.

No cost analysis was carried out prior to the Management Board's decision not to site a centralized interim storage facility. The Board's decision was based instead on two other important criteria, namely:

(1) an analysis of regulatory requirements for establishing such a facility; and

(2) the needs expressed by small-volume LLRW generators.

Because only three respondents to the 1990 survey of radioactive materials users (out of a total of over 450 users) expressed some need, the Board felt such an action was unnecessary at the time. The Board also voted to review its decision periodically.

The total costs to site, develop, and license a Massachusetts centralized storage facility are unknown. However, some financial assumptions can be made by evaluating two preliminary cost analyses conducted by officials of New York State.

The first study was published by the New York State Energy Office in April, 1984, and included a recommendation that the State develop an interim centralized storage facility for Class A[27] LLRW. The Energy Office also recommended that the storage facility be located at the West Valley, New York, LLRW site that operated from 1963 until it was closed in 1975.

In the 1984 study, New York considered three basic design concepts in its cost evaluation, which included:

(1) a "warehouse" building, possibly prefabricated, placed on a concrete slab;

(2) a "warehouse with incinerator" concept which would include an on-site incinerator; and

(3) an "overpack" design, which would utilize reinforced concrete containers holding 55-gallon drums that would be sealed, shut, and stacked on a concrete slab.

The "rough" cost estimates projected in this New York study assumed that only non-utility Class A LLRW would be stored at West Valley (property owned by the State of New York), and that the average yearly volume of waste -- 70,000 cubic feet -- would be stored for five years.

The costs for each concept, which included design, construction, equipment, licensing, management, operation, maintenance, and decommissioning are depicted on Table 12-1, for both 1984 and 1993 dollars.

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[27] Class A waste is one of four classifications made by the NRC for purposes of LLRW disposal. Class A wastes have the lowest levels of radioactivity under the NRC system. Additional information on Class A, as well as on the other NRC waste disposal classes (Classes B, C, and Greater-than-Class-C), is contained in Chapters 4 and 7 of this volume.

Table 12-1 Rough Cost Estimates of Centralized Storage at West Valley, N.Y.			
	1984 Dollars	1993 Dollars	Total Cost (1993) 350,000 cubic feet
Warehouse	$53/cubic feet	$74/cubic feet	$25,900,000
Warehouse with incinerator	$79/cubic feet	$110/cubic feet	$38,500,000
Overpack	$61/cubic feet	$85/cubic feet	$29,750,000
Source: EG&G Idaho, Inc. Proceedings of the Seventh Annual Participants' Information Meeting DOE Low-Level Waste Management Program. CONF-8509121, Idaho Falls, ID, February, 1986.			

New York completed another study for centralized storage of LLRW in 1993.[28] For study purposes, the facility was nominally designed to accommodate LLRW from medical and academic institutions, only. Four cases were evaluated that established upper and lower bounds for facility user fees. These four cases are defined, and their cost implications are described in Table 12-2.

California has also evaluated the interim centralized storage concept, and estimated that such a facility would cost $24,805,400 to construct, including site acquisition (in 1993 dollars). California also concluded that a treatment facility would be necessary to process its flammable and biological LLRW.

Table 12-2 Cost Estimates for Centralized Storage of Only Academic and Medical LLRW in New York State			
Storage Case Studied	Total Volume, cubic feet	Unit Cost, 1993 dollars/ cubic feet	Total Facility Cost, dollars
Case I - Base Case: All medical and academic LLRW, including freezer storage	115,756	$408.54	$57,017,032
Case II - Same as Case I without freezer storage (incineration of biological waste off site)	104,173	$408.54	$54,778,983
Case III -Lower Bound Case: Site and facility available; only modifications required; licensed activities already present; pharmaceutical generators added	127,731	$315.92	$48,767,625
Case IV - Upper Bound Case: High site development costs and low storage volumes	65,031	$1,139.82	$88,908,569
Source: New York State Energy Research and Development Authority. Low-Level Radioactive Waste Storage Study, Vol. II: Centralized Storage Facility. Albany, NY, October, 1993.			

The relative magnitudes of these costs are interesting as they pertain to various centralized storage configurations. However, because these models are only useful for the assumptions that underlie their estimates, their use to identify the real costs of a Massachusetts centralized storage facility is impractical. This is principally due to the multitude of variables involved, including facility size, waste form, radionuclide composition, the numbers of LLRW generators needing such a facility, etc.

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[28] New York State Energy Research and Development Authority. Low-Level Radioactive Waste Storage Study, Vol. II: Centralized Storage Facility, Albany, NY, October, 1993.

Many of the factors that must be considered in evaluating cost-effectiveness of storage options are identified in the matrix shown in Table 12-3. While this matrix is not intended to be all inclusive, it is representative of the type of analysis that must be completed to determine the most cost-effective storage technologies and practices.

Estimates for each activity and option need to be inserted into the matrix and then totalled to identify the most cost-effective solution. These costs need to be presented on a present value basis[29] to provide an accurate and reliable comparison. Once this exercise has been completed, other factors such as the economic viability of Massachusetts radioactive materials users, as well as environmental and political considerations, must also be carefully analyzed.

Table 12-3
Factors Relative to Cost-Effectiveness of Storage

Factors Affecting Storage Costs	Storage Options					
	On-Site		Centralized[1]		Broker	
	Cost to Generator	Cost to State	Cost to Generator	Cost to State	Cost to Generator	Cost to State
Site selection	X			X	X	
Licensing	X	X	X	X	X	
Environmental Review	X		X	X	X	
Storage Facility Design	X			X	X	
Operating Procedure	X	X	X		X	
Waste Characteristics	X		X		X	
Treatment before Storage	X		X		X	
Manpower	X		X		X	
Personnel Monitoring	X		X		X	
Environmental Monitoring	X		X		X	
Packaging	X		X		X	
Health Risks:						
Doses to Public	X		X	X	X	
Doses to Workers	X		X	X	X	
Equipment	X		X	X	X	
Operating Costs	X		X		X	
Closure Costs	X		X		X	
Institutional Control[2]			X	X	X	

[29] "Present value" is the amount of money which, if invested at risk-free interest rates today, will compile enough interest so that the sum of the principal plus the accrued interest will equal the required future costs.

Table 12-3
Factors Relative to Cost-Effectiveness of Storage
(continued)

Factors Affecting Storage Costs	Storage Options					
	On-Site		Centralized[1]		Broker	
	Cost to Generator	Cost to State	Cost to Generator	Cost to State	Cost to Generator	Cost to State
Decommissioning	X		X	X		
Land Acquisition	X			X	X	
Transportation			X		X	
Waste Segregation	X		X	X	X	
Community Impact Payments			X	X	X	
Construction Costs	X		X	X	X	
Amortization	X		X	X	X	
Interest Costs	X		X	X	X	
Inspection		X	X	X	X	
Special Handling	X		X	X	X	
Liability	X		X	X	X	
Emergency Preparedness and Response		X	X	X	X	
Repackaging	X		X			
ALARA[3]	X		X			
Training	X	X	X	X	X	
Impact on Industry Competitiveness	X	X	X	X	X	X
Storage Fees			X		X	
Waste Acceptance Criteria			X		X	

1 Costs of the "centralized" storage option are shown divided among LLRW generators and the State. However, state costs could be recovered through user fees.
2 "Institutional control" is the period of continued observation, monitoring, and care of a facility following closure and post closure observation and maintenance. This period would not be expected to last as long as that of a disposal facility, since the LLRW would be removed from any storage facility at closure.
3 The "ALARA" principle is an NRC requirement that radioactive materials be used in a manner that keeps any radiation dose to workers and the public "as low as reasonably achievable."

12.7 Recommendations to Improve Safety or Efficiency

The following recommendations are based upon the factors discussed earlier in this section relative

to potential health, safety, and environmental impacts of storage; its climatic, geologic, hydrogeologic and other requirements; its suitability for LLRW managed in Massachusetts, and its cost-effectiveness.

General Recommendations

Maximum use of storage for decay. Storage for decay should be encouraged to the fullest extent of each radioactive materials licensee's ability, within the constraints of the license.

As part of its short-term LLRW management policy, the Management Board will routinely review needs of LLRW generators for centralized storage. Such a facility could be utilized for a short period of time, perhaps 5-10 years, until disposal solutions are available. As was noted earlier in this chapter, the Management Board has twice determined the impracticality of siting and developing a facility for interim storage for only the three small-volume LLRW generators identified from the 1990 annual survey who requested such a facility. The ability of all LLRW generators to store their waste on-site should be re-assessed periodically, to determine whether the 1990 situation has changed.

Recommendations to Ensure Environmental Protection

Discourage less environmentally-sound storage practices. Storage of LLRW in ways that increase the potential for environmental or public health damage -- such as interim storage outside in a manner that exposes waste packages to changes in climate -- should be discouraged.

Packaging should ensure environmental and public health protection throughout storage period. All waste requiring interim or long-term storage should be packaged in ways that ensure environmental and public health protection. In planning for storage, LLRW generators need to be cognizant that packaging, treatment, and disposal standards could possibly be modified during a storage period, thereby requiring LLRW to be repackaged for ultimate disposal.

Monitor storage of wastes at old burial sites undergoing decommissioning. Because the future status is unclear regarding on-site storage for LLRW and mixed waste at old burial sites where decommissioning and remediation is being performed, the Management Board will communicate with the federal and state agencies supervising such cleanups, and will monitor their actions, to ensure that responsibility endures for the observation and maintenance of stored waste, even after such sites are remediated or decommissioned.

Recommendations to Ensure Environmental Protection, Public Safety, and Worker Safety

Stabilize potentially problem waste for long-term storage. Long-term storage should be encouraged only after all potentially troublesome waste has been processed for reasonable stability.

Treat all LLRW before long-term storage. Long-term storage should be encouraged only after all treatable waste has been processed to achieve reasonable volume-reduction levels in order to reduce the amount of waste ultimately requiring disposal.

Provide appropriate number of personnel to monitor storage. The Commonwealth should provide an adequate number of qualified personnel in the Department of Public Health's Radiation Control Program to ensure its capability to perform necessary inspection and enforcement activities.

Recommendation to Ensure Public Safety

Notification to municipal officials of storage activities. Procedures should be established to

encourage generators which will be storing all LLRW on site to notify and educate municipal officials about the uses of radioactive materials by each licensee, and the types, forms, and characteristics of waste in storage.

Recommendation to Ensure Operational and Worker Safety

Provide technical assistance on storage issues. The Commonwealth should make available to LLRW generators technical assistance on storage problems.

Recommendation to Ensure Economic Protection for the Commonwealth

Generators' responsibility for repackaging waste in storage. If a centralized storage facility is developed in Massachusetts, any LLRW that may later require repackaging for disposal will be the financial responsibility of the generator.

Recommendation for Regulatory Actions to Ensure Safe and Efficient Storage

Encourage MOU between non-Agreement State licensees and DPH regarding storage. Because the two nuclear-powered utility companies, the three university research reactors, and federal facilities (such as Veterans Administration hospitals) will continue to be licensed by the NRC after Massachusetts becomes an Agreement State -- and therefore will not be subject to the regulatory authority of DPH -- the Commonwealth and the non-Agreement State licensees (especially the utilities because of the volumes of waste they generate) should develop an understanding that any interim or long-term storage will be consistent with DPH storage requirements.

12.8 Chapter References

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Chapter 13: Providing Disposal Capacity for LLRW Generated in Massachusetts

13.1 Introduction

This chapter is the last in a series that reviews treatment, storage, and disposal technologies and practices used to manage low-level radioactive waste (LLRW). Chapter 11 addresses "treatment" as an element of management; Chapter 12 evaluates "storage" issues, and this chapter assesses factors relating to LLRW "disposal."

This chapter analyzes disposal technologies and practices for their potential health, safety, and environmental impacts; their climatic, geologic, and hydrogeologic requirements; their suitability for the LLRW managed in Massachusetts, and their cost-effectiveness. Chapter 13 also summarizes federal and state regulations pertaining to LLRW disposal, and offers recommendations to improve the safety or efficiency of disposal technologies and practices, in the event that an LLRW disposal facility is built in the Commonwealth.

13.2 Defining LLRW "Disposal"

LLRW disposal is defined by Massachusetts law as the isolation of the waste from the biosphere[1] inhabited by human beings and their food chains. [Massachusetts General Laws c.111H (Chapter 111H), section 1] And as will be shown, this definition has a different connotation for implementing "disposal" actions, than do federal regulations.

The Massachusetts definition differs from the definition of LLRW disposal found in federal regulations. The U.S. Nuclear Regulatory Commission (NRC), whose federal responsibility covers the regulation of LLRW disposal facilities, also includes in its definition the phrase "by emplacement in a land disposal facility."

The NRC's disposal standards, which are based on the shallow land burial disposal method, took effect in 1983, 21 years after the first commercial LLRW disposal site began operation in Beatty, Nevada. The Nevada site, and the three current commercial disposal sites in operation in Utah, Washington, and South Carolina, use the shallow land burial method. In addition, three other LLRW disposal sites operated between 1962 and 1979[2] with the same method of burying LLRW in shallow trenches near the earth's

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[1] The biosphere is that part of the earth's crust, waters and atmosphere where living organisms can subsist.

[2] The three closed LLRW disposal sites are located in Kentucky, New York, and Illinois. Details about these sites, and the reasons they were closed, as well as the Nevada, South Carolina, Utah, and Washington sites, are contained in Appendix 1A, following Chapter 1.

surface, and the NRC has granted licenses to individual radioactive materials users to dispose of LLRW on the licensee's property, although this practice has been discouraged since the mid-1980s.

Shallow land burial, sometimes also referred to as "near-surface disposal," is one of three major elements in the NRC's disposal program, which the agency terms a "multi-barrier" approach. Shallow land burial relies on the natural characteristics of the land itself as the "primary" barrier for isolation of the waste. The second NRC barrier is the amount of radioactivity allowed in the disposal containers, as determined through the NRC's A,B, and C classification system.[3]

The third barrier in the NRC's system is based on NRC's requirements relating to the characteristics or "form" of the wastes allowed in a disposal facility. For example, these characteristics prohibit the disposal of liquid waste unless it is packaged with absorbent that will hold twice the amount of liquid in the waste.

The authors of Chapter 111H, the Massachusetts Low-Level Radioactive Waste Management Act; the public who reviewed and commented on the draft law; the Legislature that overwhelmingly approved the proposal,[4] and the Governor who signed it into law, all disagreed with the NRC and its characterization of "improved shallow land burial" as an acceptable disposal method.

Because there is significant concern that environmental damage and health impacts have a greater potential to occur when any type of harmful substance is placed into the land, the Massachusetts law **explicitly prohibits** shallow land burial of LLRW.[5] [Chapter 111H, section 16(a)] In addition, the Massachusetts statute requires that any LLRW disposal facility **must** permit the waste to be **monitored** continuously and **retrieved** if necessary for corrective action.

Along with the monitoring and retrieval requirements is another in Chapter 111H that is related to the State's different view of "disposal." This is the requirement that the institutional control period for any facility "shall not be less than the minimum time required for any LLRW present at the site to decay to the maximum concentrations above natural background levels permitted to be released into air or water in unrestricted areas under federal and state law." [Chapter 111H, section 46(b)] Because of this requirement, the institutional control period at a Massachusetts disposal facility could last 300 to 500 years or longer, depending upon the half-lives and concentrations of radionuclides disposed of at the facility. Or, the Commonwealth could remove any remaining radioactive waste from the disposal facility, and place it into a new facility. On the other hand, NRC regulations specify that institutional control for purposes of observing, monitoring, and maintaining a disposal facility, should last a "maximum" of 100 years. [Title 10, Code of Federal Regulations (CFR) 61.59(b)]

These provisions (i.e., prohibition on shallow land burial, requirements for waste monitoring and waste retrieval, and maintaining the institutional control period as long as necessary for waste to decay to maximum concentrations above natural background levels), are all intended to ensure that State government

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[3] A discussion of the NRC classification system for disposal, and the Massachusetts classification system for storage, treatment and disposal, is contained in Chapter 7.

[4] Many Massachusetts citizens and public officials testified in favor of prohibiting LLRW in landfills at the numerous public hearings which were held throughout the State prior to the submission of Chapter 111H to the Legislature. In 1987, Chapter 111H was approved unanimously by the Massachusetts Senate, and with the objection of only one member of the Massachusetts House of Representatives.

[5] The Massachusetts law, however, does not prohibit the use of vaults or other engineered structures, holding containers of LLRW, which could be placed into the earth's surface. Near-surface burial or shallow land burial implies that waste packages are placed directly into the land, with no other protections.

never "walks away" from an LLRW disposal site, unless the site is free from radioactive contamination. For these reasons, an LLRW "disposal" facility in Massachusetts is analogous to very, very long-term storage.

Fitting the Massachusetts Definition into NRC Requirements

The words used by the NRC to define "disposal" have caused confusion to some who question whether any technology other than shallow land burial is permitted under the agency's regulations. However, NRC has made its position clear that alternative disposal technologies are perfectly acceptable as long as they can fulfill the minimum performance standards and other requirements in their regulations, Title 10, Part 61 of the Code of Federal Regulations, (10 CFR Part 61), which apply to land disposal facilities.

What this means is that any disposal (a.k.a. very long-term storage) facility that may have to be built in Massachusetts can be sited, designed, constructed, and operated using the more stringent requirements of Chapter 111H, because they meet (and exceed) the minimum requirements of the NRC's regulations.

If such a facility is determined to be necessary in Massachusetts, either the State or the NRC will license and regulate the facility, depending upon which level of government is authorized to do so. State authority to regulate a disposal facility has to be assigned to the State by the NRC, and the state program must be consistent with NRC requirements. The transfer of licensing authority occurs if Massachusetts becomes an "Agreement State."[6] Based on recommendations from the Massachusetts Department of Public Health (DPH) and the Massachusetts Low-Level Radioactive Waste Management Board, Governor William F. Weld made official application in July, 1992, for the Commonwealth to become an Agreement State. The NRC's review and approval process generally takes two years or longer.

Key elements of Chapter 111H relate to LLRW disposal. The law in its entirety is contained in Appendix A at the end of this Management Plan volume, and is summarized in Chapter 2. However, for the purposes of this chapter, which reviews and analyzes current and developing LLRW disposal technologies, the critical provisions of Chapter 111H are:

- shallow land burial of LLRW is **prohibited**;
- the process of identifying potential sites for a disposal facility is handled strictly on the basis of environmental criteria and environmental suitability;
- the public is involved in every phase of site identification work;
- the potential site community may undertake an independent analysis of site characterization data collected to determine the validity of a site;
- a **local committee of citizens and officials** from the site community has a major role under the law: it **selects** the type of disposal technology that it feels best protects the community's interests, and
- **the local committee of citizens and officials chooses** the company (from a list of certified facility operators) that it determines is most capable of building and operating the disposal facility to protect the public's health, welfare, and the environment.

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[6] Details of the NRC's Agreement State program, and the process for receiving approval, are described in Chapter 2.

13.3 LLRW Disposal Regulations

Every disposal facility must meet four minimum NRC performance objectives during siting, design, operation, closure, and institutional control (after facility closure), to ensure that radiation exposures to people are within the limits set by federal regulation. They are:

(1) Any radioactive material that leaves the disposal facility and enters the general environment through ground water, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 millirem to the whole body, 75 millirem to the thyroid, and 25 millirem to any other organ of any member of the public.[7] [10 CFR 61.41] This limit compares to a yearly national average of 360 millirem an individual receives from exposure to natural and man-made radiation. Of that total, approximately 29 millirem is a result of exposure to cosmic radiation (29 millirem at sea level; more at higher elevations); 29 millirem is due to exposure from the earth's surface; and 24 millirem results from exposure from the food, water and air we eat, drink, and breathe.

(2) A facility must be designed, operated, and closed to ensure that any person who inadvertently enters the facility disposal area and decides to remain at the site, or comes in contact with the waste after the institutional control period ends, will not receive more radiation than 500 millirem to the whole body in one year. [10 CFR 61.42]

(3) A facility must be operated in compliance with the radiation protection standards established by the NRC in 10 CFR Part 20 and the maximum allowable releases of radioactivity identified in (1), above. [10 CFR 61.43]

(4) A facility must be sited, designed, used, operated, and closed to achieve long-term structural stability so that ongoing, active maintenance and repairs will not be necessary. The facility must be structurally sound so that only surveillance, monitoring or minor custodial care are required. [10 CFR 61.44]

Other NRC regulations [e.g., 10 CFR 61.52] pertain to the way in which waste is placed into the disposal facility, and must be implemented by any Massachusetts facility operator. They include:

(1) Waste classified as "Class A, unstable"[8] must be segregated from other waste in the disposal facility.

(2) Class C waste must be placed into a disposal facility so that the top of the waste container is a minimum of 16.4 feet below the top of the facility cover. For a disposal facility that is built above the ground, Class C waste must be disposed of to meet this 16.4 foot requirement, <u>or</u>

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[7] A "millirem" is a measurement of the radiation energy absorbed by biological tissue from a dose of ionizing radiation. A millirem is one thousandth of a "rem." "Whole body" dose is to be interpreted to mean "effective dose equivalent" wherever it appears in this Management Plan. The former term is used in many regulations and documents cited herein, and is retained in the text for consistency with these documents. The latter term represents recent changes in expressing dose.

[8] "Class A, unstable" wastes are those that fall into the Class A category (i.e., they are characterized by their low concentrations of long-lived radionuclides and concentrations of short-lived radionuclides that will decay to acceptable levels within the assumed 100-year institutional control period) which have no structural stability.

be surrounded by additional barriers to protect "intruders" for at least 500 years (e.g., by the use of High Integrity Containers).[9]

(3) Waste must be placed into a disposal facility in a manner that maintains the integrity of the package, minimizes void spaces between packages, and allows those spaces to be filled.

(4) Void spaces between packages must be filled.

(5) Waste must be placed into the facility and covered in a manner to ensure that when the institutional control period begins, dose rates are no greater than that allowed in an "unrestricted area" (i.e., not in excess of 2 millirem per hour and 500 millirem to the whole body in one year).

(6) The boundaries of all disposal units must be mapped by a land survey.

(7) A buffer zone of land must be maintained by the facility operator.

DPH Requirements

DPH licensing regulations, which meet (and in some cases exceed), the NRC requirements, will be substituted for the federal provisions, once Massachusetts becomes an Agreement State. In addition to the performance objectives identified in the NRC regulations and other NRC requirements with which DPH regulations must, "at a minimum," be compatible [Chapter 111H, section 16], Chapter 111H requires DPH regulations to:

- ensure any disposal facility method "shall permit retrieval and monitoring of the waste;"
- prohibit shallow land burial; and
- regulate facilities for mixed waste[10] "at an equivalent level of environmental protection, as is provided for hazardous waste under the provision of the State's hazardous waste management law.

"Zero Release" Design Objective

In addition to the requirements mandated in Chapter 111H, DPH regulations include a "facility design objective" intended to ensure "zero release" of radioactivity from the engineered structures designed for LLRW disposal. The explicit language of the DPH regulation, in 105 Code of Massachusetts Regulations (CMR) 120.815(E), is as follows:

> "Any disposal facility shall have its engineered structures designed with the goal to totally hold their waste content for the period of the hazardous life of the radioactive waste (zero release design objective)."

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[9] "Class C" waste is that which, due to its greater concentrations of long-lived or short-lived radionuclides, has to meet waste stability requirements for the form of the waste, or the container which holds it (300 year minimum). Additional information about all the NRC classes of waste can be found in Chapter 7.

[10] "Mixed waste" is LLRW that contains, or exhibits characteristics of, toxic chemical "hazardous waste."

Minimum Technical Site Requirements

If a disposal facility is determined to be needed In Massachusetts, technical requirements for identifying a disposal site, and licensing and operating a dlsposal facility, are contained In state law as well as in NRC regulations. As previously noted, the federal requirements must be met, even if Massachusetts becomes an Agreement State to regulate a facility at the state level.

The pertinent Massachusetts statute relating to LLRW disposal, Chapter 111H, requires that "the primary consideration in adopting such regulations shall be the protection of public health, safety, and the environment." [Chapter 111H, section 14(a)]

The technical siting requirements outlined in Chapter 111H, section 14(b) "shall ensure, at a minimum, that any superior site[11] satisfies the following:"

(1) Sites shall be capable of being characterized, modeled, and monitored;

(2) Sites shall be well-drained and free of areas of flooding or frequent ponding; waste management areas[12] shall be outside any 100-year flood plain, coastal high-hazard area, or wetland;

(3) Upstream drainage areas shall be minimized to decrease the amount of runoff that could erode or inundate the waste management area;

(4) Sites shall provide sufficient depth to the water table so that groundwater intrusion, perennial or otherwise, into the waste will not occur;

(5) The hydrogeologic unit used for waste management shall not discharge groundwater to the surface within the site;

(6) Waste management areas shall be located so that tectonic processes in the vicinity, such as faulting, folding, seismic activity or volcanism, will not occur which will significantly effect the ability of the site to meet any performance objectives adopted by the DPH relative to environmental and human exposure to radiation, or preclude adequate modeling and prediction of long-term impacts;

(7) Waste management areas shall be located so that surface geologic processes in the vicinity (such as mass wasting, erosion, slumping, or weathering) will not occur to the extent that it would significantly affect the site's ability to meet DPH's performance objectives, or preclude adequate modeling and prediction of long-term impacts;

(8) Waste management areas shall be located so that nearby activities will not adversely affect the ability of the site to meet any DPH performance objectives or significantly impair the

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[11] A "superior site" Is any site selected by the Management Board following a series of environmental reviews of available lands throughout the state. These environmental evaluations include a detailed hydrogeologic characterization of a site, spanning four seasons of the year.

[12] A "waste management area" is "that portion of a facility where LLRW has been, is belng or will be treated, stored or disposed of." The "site" is the entire parcel of land which makes up a facility, Including buffer areas between the waste management area and the facility boundary, and areas which occupy structures and equipment.

environmental monitoring program;[13]

(9) Sites shall be located in areas with no known economically recoverable resources which, if exploited, would adversely affect the ability of the site to meet any DPH performance objectives or significantly impair the environmental monitoring program;

(10) Sites shall be located outside of, and so as not to adversely affect, the recharge zones of existing or future drinking water source aquifers;

(11) Sites shall have sufficient land available to provide for the waste volume and a reasonable buffer around the waste management area;

(12) Sites shall be located so as not to adversely affect any national park, monument, lake shore, endangered species habitat, or area protected by the federal Wilderness Act, the federal Wild and Scenic Rivers Act, the federal Fish and Wildlife Coordination Act, or the federal National Historic Preservation Act; and

(13) Sites shall be located away from any structure or area in which are regularly found persons who, because of their age or physical characteristics, are likely to be at significantly higher than normal risk of adverse health effects if exposed to the release of radioactive or associated toxic materials.

No Waiver of Regulations Allowed

An unusual provision of Chapter 111H appears in the law after the list of minimum site suitability requirements. Paragraph (d) of section 14 prohibits both the Department of Environmental Protection (DEP) and the Management Board from waiving, or excluding from consideration, any of the site selection criteria. Other siting processes in Massachusetts and other states have attempted to waive certain criteria in the interests of site selection expedience. Such waivers have engendered popular controversy and undermined public credibility of those siting processes. Chapter 111H prohibits such usurpation of the law's intent.

DEP Regulations

In addition to the regulations cited above, any disposal facility that may be established in Massachusetts would also have to be licensed by DEP (in addition to the license required by NRC or DPH), if "mixed" waste were accepted at the facility. As noted earlier in this chapter, mixed waste is LLRW that contains material listed as toxic, chemical "hazardous" waste, or exhibits the characteristics of hazardous waste. This waste is regulated at the federal level by the EPA and at the state level by DEP.

Like DPH, which hopes to receive Agreement State authority from the NRC, DEP has applied to the EPA for "RCRA-based" authority to regulate mixed waste in Massachusetts. However, until such authority

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[13] The "environmental monitoring program" is defined as a "program established by the DPH, after consultation with the state Department of Environmental Protection (DEP) and the board of health of each site community, for the purpose of collecting and analyzing environmental data prior to construction and throughout the construction, operation, closure, post-closure observation and maintenance and institutional control [phases] of a facility." Federal regulations describe these monitoring activities as "pre-operational" monitoring, monitoring "during construction and operations," and "post-operational" monitoring. The pre-construction monitoring must last a minimum of 12 months.

is granted, DEP can regulate mixed waste disposal under Massachusetts hazardous waste regulations.[14] Those regulations allow mixed waste to be disposed of by shallow land burial, as long as such facilities incorporate into their designs two liners and leachate collection and leak detection systems. [310 CMR 30.622] Because Chapter 111H prohibits shallow land burial for any LLRW, the more stringent controls of Chapter 111H would take precedence over the landfilling provisions allowed in DEP regulations.

Other disposal facility requirements of the DEP, which comply with EPA requirements, include installing security barriers; conducting inspections; training facility personnel; handling "ignitable," "reactive" or incompatible" wastes;[15] complying with siting standards; and providing for emergency preparedness, financial assurance, closure and post-closure, and corrective action. NRC regulations have similar, if not identical, requirements for disposal facilities.

The EPA's hazardous waste facility requirements have been challenged by some states building LLRW disposal facilities for the extra costs associated with regulatory standards that some believe provide no extra protection for the public or the environment. For example, the state of Nebraska is building an above-ground warehouse-type LLRW disposal structure, into which it will place packages of LLRW in vaults built inside the "warehouse." The entire disposal facility will be connected to monitoring equipment, which will be designed to alert the facility operator if any waste is released from its packaging or its vault. Such a monitoring system will allow the operator to retrieve the waste long before it comes into contact with groundwater or other potentially contaminating pathways.

Nebraska officials question the environmental justification for a double liner when their disposal facility is not a landfill. They estimate that they would have to charge LLRW generators about $1,200 per cubic foot of mixed waste to cover the extra costs of the EPA liners, since a very small quantity of mixed waste is expected to be generated. This fee compares to the $200 per cubic foot fee estimated for non-mixed LLRW in the Nebraska facility. For these reasons, Nebraska has decided that its disposal facility will not accept any mixed waste.

13.4 Existing Disposal Activities in Massachusetts

Through 1992, most of the LLRW produced in Massachusetts was disposed of in the three shallow land burial commercial disposal sites used by the nation's generators of LLRW. As noted, these sites are located in South Carolina, Nevada, and Washington, and are described in Appendix 1A following Chapter 1. Since Jan. 1, 1993, the only major LLRW disposal site available to Massachusetts generators has been the Barnwell, South Carolina site. This is due to the fact that the site in Beatty, Nevada, ceased to operate on Dec. 31, 1992, and the site in Hanford, Washington, ceased accepting LLRW from outside the Northwest and Rocky Mountain Compact regions[16] on that same date.

The Management Board successfully executed a contract for access to the Barnwell site, but that contract is scheduled to end on June 30, 1994. Unless that contract is extended, which would require a

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[14] This is not the case for DPH, which cannot assume any regulatory control from the NRC until Agreement State approval is granted. Please refer to the discussion of the Agreement State program in Chapter 2 of this volume.

[15] All of these types of mixed waste are described in Chapter 8.

[16] Descriptions of these compact regions can be found in Chapter 6.

vote of the South Carolina Legislature, all LLRW generated in Massachusetts will have to be stored on site until the Commonwealth identifies an alternative disposal solution.

Some LLRW can also be shipped for disposal to a fourth site that is available for certain types of LLRW. This site, located in Clive, Utah, is primarily a disposal site for Naturally-occurring and Accelerator-produced Radioactive Material (NARM), a type of radioactive waste that is not regulated by the NRC. However, the site, owned and operated by Envirocare of Utah, Inc., also accepts high-volume, low-activity LLRW containing certain radionuclides of particular low concentrations, such as contaminated soils and building rubble.

The amount and radioactivity of the LLRW shipped for disposal to these sites, as well as other pertinent data on LLRW generated in Massachusetts, is discussed in Chapter 4.

In addition to the land disposal of LLRW, other disposal methods are authorized in regulations of the NRC. That agency, the current regulator of radioactive materials users in the Commonwealth, allows LLRW containing very small amounts of radioactivity to be disposed of through such alternative disposal methods as discharge to sewer systems and to the atmosphere. These methods are discussed in Chapter 10 in connection with various waste minimization practices.

Discontinued Disposal Practices

Prior to the adoption of the NRC's disposal regulations in 1983, licensed users of radioactive materials were legally allowed to bury on site certain types and quantities of LLRW. A handful of Massachusetts radioactive materials users followed this procedure until they were discouraged from burying wastes on their properties.

In 1990, when a newspaper account appeared that described LLRW buried years before at an industrial site in Grafton, Massachusetts, the Management Board sought more information about the company's past actions, and met with company and municipal officials to discuss testing and remediation procedures.

A second newspaper account of an old burial site in Worcester prompted the Management Board to direct its staff to begin to identify and document all LLRW buried in the Commonwealth.

This information continues to be collected. The Management Board has contacted every municipal Board of Health, and all regional DEP offices, requesting any information about possible old burial sites. In addition, the Board has contacted the NRC, and is seeking information from the files of the NRC's predecessor agency, the U.S. Atomic Energy Commission (AEC). Because all old AEC files were placed in storage after the agency ceased to exist, records of old burial activities that had been approved by that agency have been difficult to locate. The NRC has hired a consulting firm to sort through all the AEC records and to establish a list of formerly-authorized and suspected old burial sites.

The Management Board has already inventoried several old burial sites from information supplied by NRC, DPH, and other sources. These sites are:

(1) Army Materials Technology Laboratory, Watertown;

(2) Engelhard Company, Plainville;

(3) General Services Administration, Watertown;

(4) Interstate 190 access ramp, Worcester (site of LLRW burial by the Norton Company of

Worcester);

(5) Harvard University's campus in Southboro;

(6) Nuclear Metals, Inc., Concord;

(7) Shpack Landfill, Norton;

(8) Texas Instruments, Attleboro;

(9) Wyman-Gordon, Grafton; and

(10) Ventron Corporation, Beverly.

The Management Board has three major reasons for its interest in locating old burial sites. The first relates to the need to ascertain whether the potential exists for a public health, safety or environmental risk at any of these former burial sites. Those determinations have yet to be made, although some of the sites listed above (1, 2, 3, 6, 8, and 9) have been identified by the NRC as requiring "accelerated" decommissioning, in order to remove the radioactive materials on the sites so that the properties can be released for unrestricted use. While the NRC believes that none of the sites on its list pose immediate public health, safety or environmental threats, the agency is concerned about the "potential long-term" impacts.[17]

The second reason for the Management Board's interest involves the need to monitor clean-up or maintenance activities at each site. The Management Board does not have the legal authority to force mitigation efforts. Those powers rest with NRC, DEP and the U.S. Department of Energy (DOE).[18] However, the Management Board can use its resources as a state agency to ensure site restoration, where necessary, and site monitoring, where no radiological threat is posed by the buried waste.

The third basis for the Management Board's desire to identify old burial sites is the need to evaluate whether any of the waste in these sites could ultimately require disposal in a site arranged by the Management Board.

13.5 LLRW Disposal Technologies and Practices

This section describes 11 current and developing LLRW disposal facility technologies. One of the facility "technologies" included in this discussion is "shallow land burial." This technique is defined in Chapter 111H as "a land disposal method that relies on the site's natural characteristics as the primary barrier for isolation of the waste."

As noted earlier, shallow land burial is explicitly prohibited as an LLRW disposal method under Massachusetts law. [Chapter 111H, section 16] It was not considered to be a "technology" by the authors

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[17] Additional information about the decommissioning activities at these sites is contained in Chapter 14.

[18] The Shpack Landfill and Ventron sites have been designated as sites requiring cleanup by the DOE through its "Formerly Utilized Sites Remedial Action Program, or FUSRAP, because the radioactive wastes buried at these locations resulted from work done under old federal contracts. See Chapter 14 for additional FUSRAP sites information.

of the statute. However, a brief description of shallow land burial is included here as a frame of reference to help evaluate the characteristics of other possible LLRW disposal methods.

The 11 current and developing technologies described here fit into three major categories: (1) below ground-level, (2) above ground-level and (3) a combination of "above" and "below" technologies. All but one of these disposal methods incorporate into their designs one or more "engineered barriers," i.e., man-made structures or devices that enhance the site's natural characteristics as a waste barrier and, therefore, are significant improvements on the basic shallow land burial disposal method. For the purpose of this analysis, barriers made from clay or other earthen materials are not considered "engineered barriers," although they can act as barriers to humans, animals, and plants, and can enhance disposal site performance.

Table 13-1 lists the alternative disposal technologies evaluated here, indicates whether they include engineered features (and how many), and identifies which could meet the "retrievability" requirements of state law.

Several of the disposal technology descriptions in this chapter are based on the Rogers and Associates Conceptual Design Report published in 1987 for DOE.[19] The Rogers study used a series of common assumptions to evaluate each disposal technology. These assumptions included:

- Each design complies with NRC disposal facility regulations, 10 CFR 61.
- Each disposal technology design would accept for disposal about seven million cubic feet of LLRW over 30 years (235,000 cubic feet per year).
- Waste volume was composed of 95% Class A, 2% Class B, and 3% Class C (the national mix at the time of the report's preparation).
- The characteristics of the waste and the radioactive waste source term[20] were based on the same assumptions used by the NRC in preparing its Draft Environmental Impact Statement for the analysis of its disposal facility licensing requirements, 10 CFR Part 61.
- Structures made of concrete (such as vaults, etc.) were assumed to fail within 500 years.
- Each site was assumed to be located in a humid region such as New England.

For purposes of analysis, the Rogers study envisioned a "worst case" scenario to set the stage for assumptions from which to derive data for very conservative provisions. It is important to note that such a scenario of people living so close to, and farming over, a waste site, would be highly unlikely, even several hundred years after facility closure.

The assumption relating to the longevity of concrete is believed no longer to be valid, given the development of certain new concrete additives that help retain the concrete's structural stability long beyond

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[19] Rogers and Associates Engineering Corporation. Conceptual Design Report: Alternative Concepts for Low-Level Radioactive Waste Disposal. DOE/LLW-60T, EG&G Idaho, Inc., Idaho Falls, ID, June, 1987.

[20] The "source term" is developed to identify what radionuclides, and what concentrations, will still be present in a disposal facility when it ceases to operate, and at the end of its institutional control period (perhaps 100 years or more after operations). Parameters used to develop a radioactive source term include the total inventory of radionuclides in the waste, their half-lives, concentrations, distribution, and the physical and chemical form of the waste.

Table 13-1 Current and Developing LLRW Disposal Facility Technologies		
Below ground level:	No. of engineered barriers: Type	Ability to meet "retrievability" standard
1. Shallow Land Burial	0	No
2. Below-Ground Modular Concrete Canister Disposal	1: Concrete canisters	Yes
3. Below-Ground Vaults	1: Vaults	Yes
4. Mined Cavity	1: Canisters or vaults	Yes
5. Borehole or Augered Hole Disposal	1: Shaft liner	Yes
Above ground level:		
6. Above-Ground Vaults	1: Vaults	Yes
7. Above-Ground Vaults with Earthen Cover	1: Vaults	Yes
8. Above-Ground Modular Canisters	1: Concrete canisters	Yes
9. Above-Ground Modular Canisters with Earthen Cover	1: Concrete canisters	Yes
Technology Mixtures:		
10. Above-Ground Vaults with Modular Canisters	2: Vaults and canisters	Yes
11. Other technology combinations, i.e., Above-Ground Vaults with Steel Boxes with Earthen Cover	2 or more	Yes

the period of time assumed by the Conceptual Design report.

In addition, certain important issues were not considered by Rogers and Associates at the time the study was conducted. For example, the technological requirements necessary for any facility to receive a permit or license in order to accept mixed waste were not addressed. In addition, the Rogers study made assumptions that each disposal technology would be used separately, rather than in combination. The estimates of potential radiation exposure to the public and to the inadvertent intruder vary significantly when some of these technologies are used jointly at one site, as is evidenced by a more recent Rogers and Associates study of an above-ground vault facility with impervious membranes, concrete roof slabs and multi-layered earthen cover. The results of that study are detailed later in this chapter in the discussion of the public health, safety, and environmental effects of above-ground facilities.

However, the Rogers study is important because it illustrates that various disposal technologies can meet the NRC's performance objectives in 10 CFR Part 61, and the DPH licensing requirements, which are summarized in section 13.3 of this chapter. The study demonstrates the feasibility of designing disposal facilities that can achieve very low doses of radiation exposure, if any, depending upon the number and type of "engineered barriers" incorporated into the facility design, and the procedures used by facility workers.

Moreover, many of the conclusions of the Rogers study are based on very conservative assumptions and technical analyses that have been refined and improved since the time of the study. These conclusions are not necessarily similar to those that would result from a study using the characteristics of the Massachusetts LLRW stream. For example, the characteristics of the waste used by Rogers and Associates

contain higher percentages of long-lived radionuclides than exist in Massachusetts LLRW, due to the assumptions made in the study of the proportions of nuclear-powered utility plant waste that would be disposed of in the model facilities. These assumptions resulted in the Rogers estimation of radiation doses to the public and to "inadvertent intruders"[21] which may be significantly higher than those that would be calculated using Massachusetts waste stream characteristics.

Below-Ground Methods

The NRC envisioned landfill-type disposal into surface and subsurface lands and slightly deeper when it promulgated its 10 CFR Part 61 disposal regulations. The two pertinent NRC definitions in the regulations are:

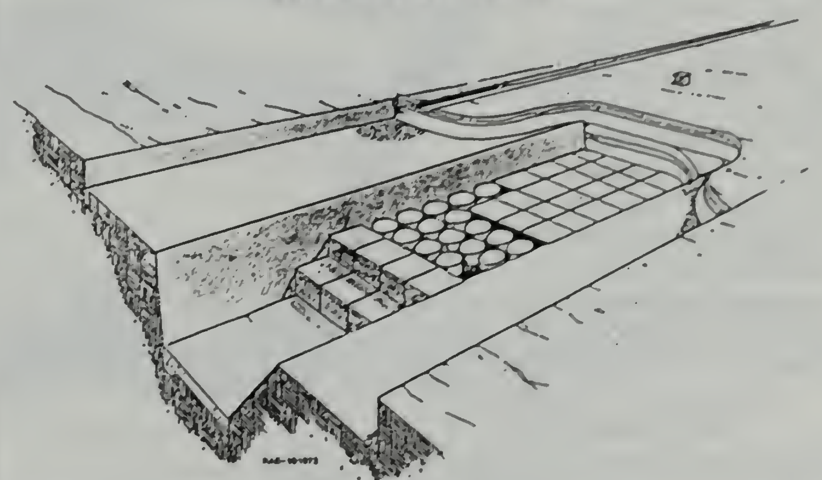
> "Land disposal facility" means "the land, buildings, and equipment which is intended to be used for the disposal of radioactive wastes into the subsurface of the land." (emphasis added)

> "Near-surface disposal facility" means "a land disposal facility in which radioactive waste is disposed of in or within the upper 30 meters (98.4 feet) of the earth's surface." (emphasis added)

(1) Shallow Land Burial

A shallow land burial site is a simple landfill in which trenches are excavated and lined with gravel, and waste containers are placed inside by stacking them in an orderly fashion. Both the void spaces filled between the containers and the "cover" placed over the trenches is made of soil, sand, gravel or other earthen material. During the operational period, while the trenches are being filled with LLRW packages, and throughout the institutional control period, possible radionuclide migration is monitored by collecting water from narrow drainage ditches that run parallel to the trenches. A typical shallow land burial site is shown in Figure 13-A.

Figure 13-A
Shallow Land Burial Site



Source: Rogers and Associates Engineering Corporation. Conceptual Design Report: Alternative Concepts for Low-Level Radioactive Waste Disposal. DOE/LLW-60T, EG&G Idaho, Inc., Idaho Falls, ID, June, 1987.

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[21] The dose to the public assumes the exposure to a family residing on a farm adjacent to the facility that uses well water for its drinking supply. An "inadvertent intruder" means a person who occupies a disposal site after its is closed, and engages in such activities as home construction or agriculture.

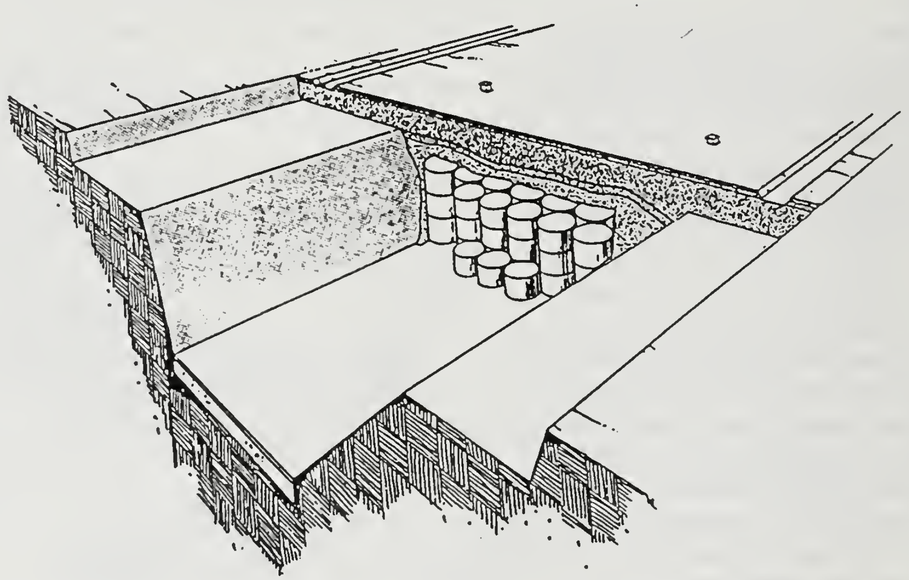
Because the natural characteristics of a conventional shallow land burial site alone may not meet the NRC "performance objectives" of long-term structural stability, the NRC regulations require that stability must be provided either by the form in which the waste is disposed of (e.g., no liquids), or by the design of the packages that hold the waste. In addition, Class C waste cannot be placed safely into this type of disposal site unless it is covered by 16.4 feet of earth material or contained in High Integrity Containers (HICs) designed to withstand the weather, corrosion, and other factors for 500 years or more.

(2) Below-Ground Modular Concrete Canister Disposal

Modular concrete canister disposal utilizes concrete canisters that are placed in shallow trenches. The canisters, also known as "overpacks," are six- and 12-foot tall steel-reinforced concrete cylinder-shaped containers that have 10 centimeter (3.9 inch) or thicker walls, and hold several individual waste packages.

Packages containing LLRW would arrive at the disposal facility and enter a building for placement into the concrete canisters. Once the canisters were sealed, they would be moved to the trenches for disposal.

Figure 13-B
Below-Ground Modular Concrete Canister Disposal



Source: Rogers and Associates Engineering Corporation. Conceptual Design Report: Alternative Concepts for Low-Level Radioactive Waste Disposal. DOE/LLW-60T, EG&G Idaho, Inc., Idaho Falls, ID, June, 1987.

In the Rogers model illustrated in Figure 13-B, Class A canisters are stacked in three tiers, and voids between them are filled with sand. Trenches for the Class B and C canisters are dug about the same depth as the Class A trenches. The canisters holding Class B and C waste are placed into the trenches in two layers, not three, so that twice as thick a cover can be placed over them.

The trenches are excavated with a gentle slope so that water will drain to one end. Thin drainage ditches filled with gravel or other coarse rock are built parallel to the trenches so that water can be sampled or pumped from standpipes located within the drains.

The concrete canisters provide a structural stability to this technology that does not exist with shallow land burial. The canisters also act as barriers to restrict water, people, plants, and animals from access to the waste. Like shallow land burial, a soil cover placed over the waste provides an extra measure of protection from radiation exposure.

(3) Below-Ground Vaults

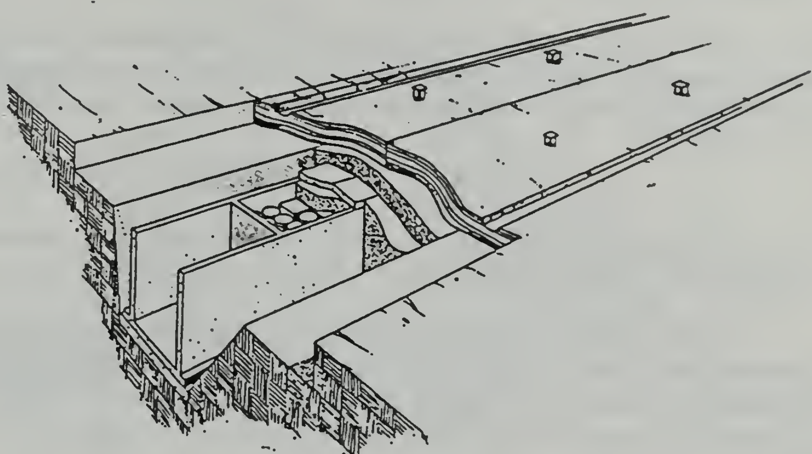
The below-ground vault disposal technology describes a totally-enclosed, engineered structure built below the earth's surface. The vaults themselves may be constructed of reinforced concrete, masonry blocks, fabricated metal, plastic, or a combination of these materials. The shape of the vault is dependent upon the type of materials used in construction.

Figure 13-C illustrates two views of a below-ground vault.

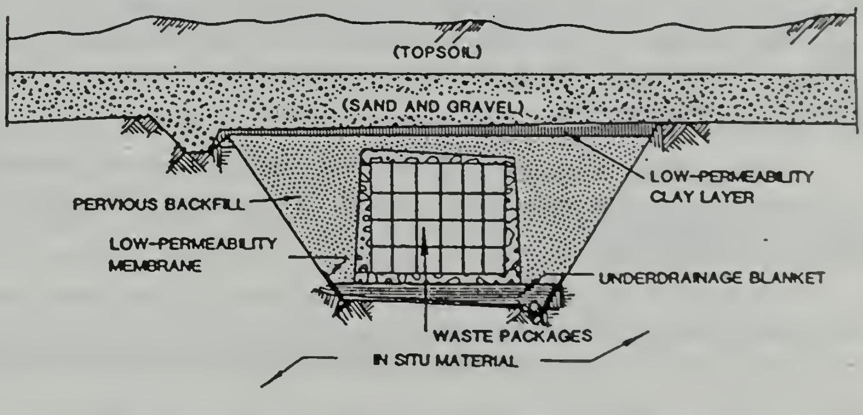
Placed on top of the vault is an earthen cover that also acts as a barrier to restrict water from seeping into the waste. Both barriers -- the concrete vault top and sides and the earth cover -- reduce water contact with the waste, prevent intrusion into the waste by humans and animals, and reduce radiation exposure at the ground level. In addition, soil and plastic covers over the concrete vault top prevent weather conditions from damaging the concrete.

A crane is used to lower waste packages into below-ground vaults, and void spaces are filled with sand or other earthen material. Class A vaults are filled to the top with waste containers, and then a roof is constructed over them. Class B and C vaults are filled only up to 6.5 feet from the top of the vault. Sand, gravel or other material is backfilled into this space, to provide extra shielding for the workers who must place the concrete roof on the vault. Once the vault roof is in place, the space between the vault and the

Figure 13-C
Below Ground Vault



Source: Rogers and Associates Engineering Corporation. Conceptual Design Report: Alternative Concepts for Low-Level Radioactive Waste Disposal. DOE/LLW-60T, EG&G Idaho, Inc., Idaho Falls, ID, June, 1987.



Source: Warriner, J.B and Bennett, R.D. Alternative Methods for Disposal of Low-Level Radioactive Wastes.Task 2a: Technical Requirements for Belowground Vault Disposal. NUREG/CR-3774, Vol.2, U.S. Nuclear Regulatory Commission, Washington, DC, October, 1985.

earthen trench walls is filled with sandy gravel.

Below-ground vault technology has been used for LLRW storage at the Chalk River Nuclear Laboratory in Ontario, Canada, and at the Whiteshell Nuclear Research Establishment in Manitoba, Canada. In the United States, this system has been used for retrievable storage of transuranic waste[22] at Oak Ridge National Laboratory in Tennessee.

Between the times that waste is being lowered into the vault, a crane could be used to swing a temporary lid of concrete or other solid material onto the vault, to help keep rain water, wind, and other weather conditions from affecting the waste packages inside. Other temporary covers or shelters could also be used for this purpose.

A drainage system underneath the vaults collects water entering below. A second drainage system collects water that seeps down the outside of the vault. All surface and groundwater is captured via sumps for monitoring throughout the period of operation, closure, and institutional control.

(4) Mined Cavity Disposal

In some parts of the United States, where mining of limestone is undertaken, the use of old underground mines for LLRW disposal is an alternative technology to the others described in this section.

Massachusetts is not a major mining state, although the extraction of sand and gravel was a lucrative business during the 19th century. Mining of minerals has been successful because of the State's reasonably abundant deposits of granite, gravel, limestone, sand, and other stones used in building construction. These minerals and crystalline rocks form many of the mountains and hills throughout the State.

A mine can be bored through rock with tunnel-boring equipment, and rooms can divide the main cavity of the facility for the disposal of different classes of LLRW.

Three types of mined cavities could be considered for LLRW disposal in Massachusetts. The shaft mine has a steep, usually vertical, shaft dug from the surface to the mine cavity, which is then dug laterally at one or more levels. A slope mine uses an inclined tunnel instead of a shaft for access to the cavity. A drift mine (Figure 13-D) is accessed through a near-horizontal shaft or tunnel, similar to the tunnels built through mountains for transportation purposes or the underground openings used for military command centers and warehouses.

The mine is described here as a "below ground-level" technology because it is cut into the earth's surface. However, the cavity and its associated tunnels may be located above sea level, bored into the side of a hill or mountain.

Concerns about groundwater infiltration into a mine cavity are frequently expressed. A mine disposal facility could be constructed at a slight down-hill grade so that any water that may potentially enter the waste storage areas or tunnels could be collected and drained through the use of a gravity system.

The mined cavity may be partially or completely lined with concrete or other synthetic materials, depending upon the structural conditions of the site. Waste can be placed into the cavity in concrete

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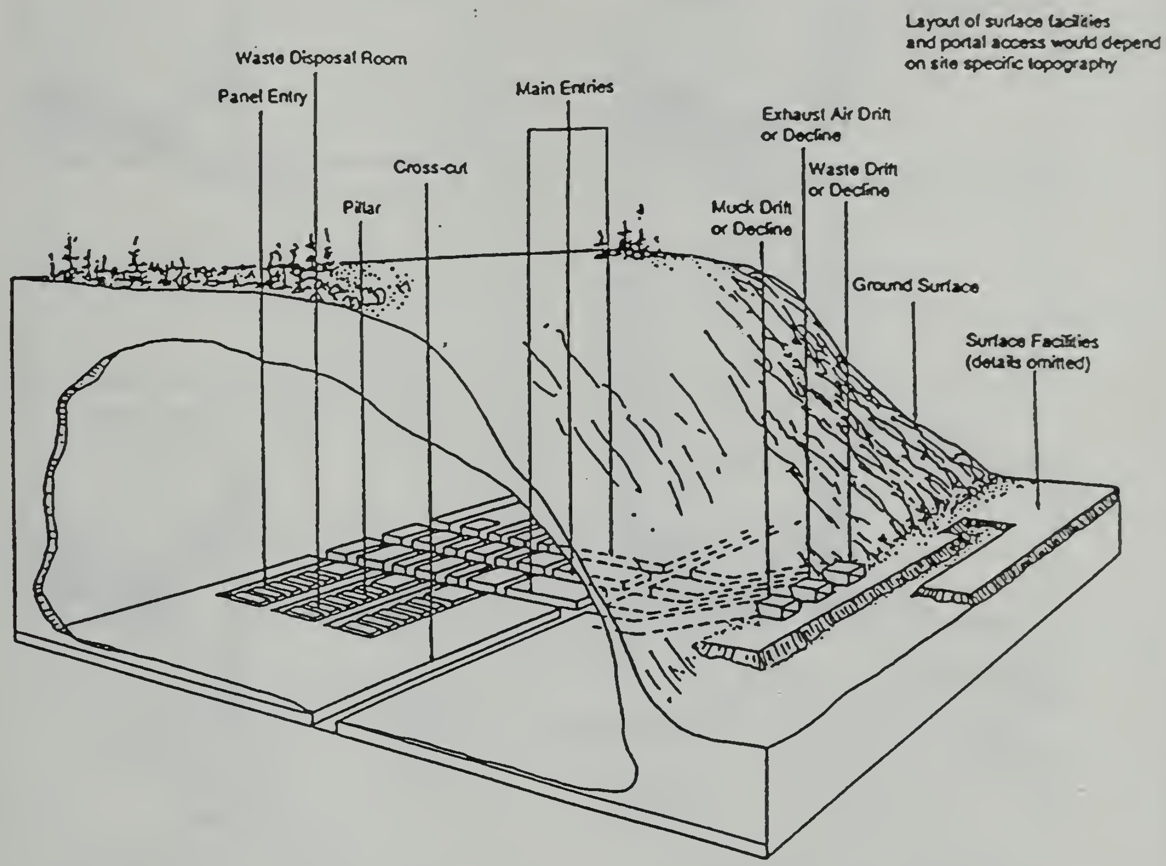
[22] "Transuranic" waste is radioactive waste containing more than 100 nanocuries per gram of alpha-emitting transuranic isotopes, with half-lives greater than 20 years. Transuranic isotopes are man-made and have atomic numbers greater than 92. They are less intensely radioactive than high-level radioactive waste.

Figure 13-D
Drift Mine for LLRW Disposal



Source: Goodale, B.G. and Golder Associates. Evaluation of the Feasibility of the Mined Repository Option. New York State Low-Level Radioactive Waste Siting Commission, Albany, NY, April, 1990.

canisters, vaults or other man-made structures, to provide added isolation and stability within the mine beyond that of the rock walls in the hill or mountain surrounding the mine.

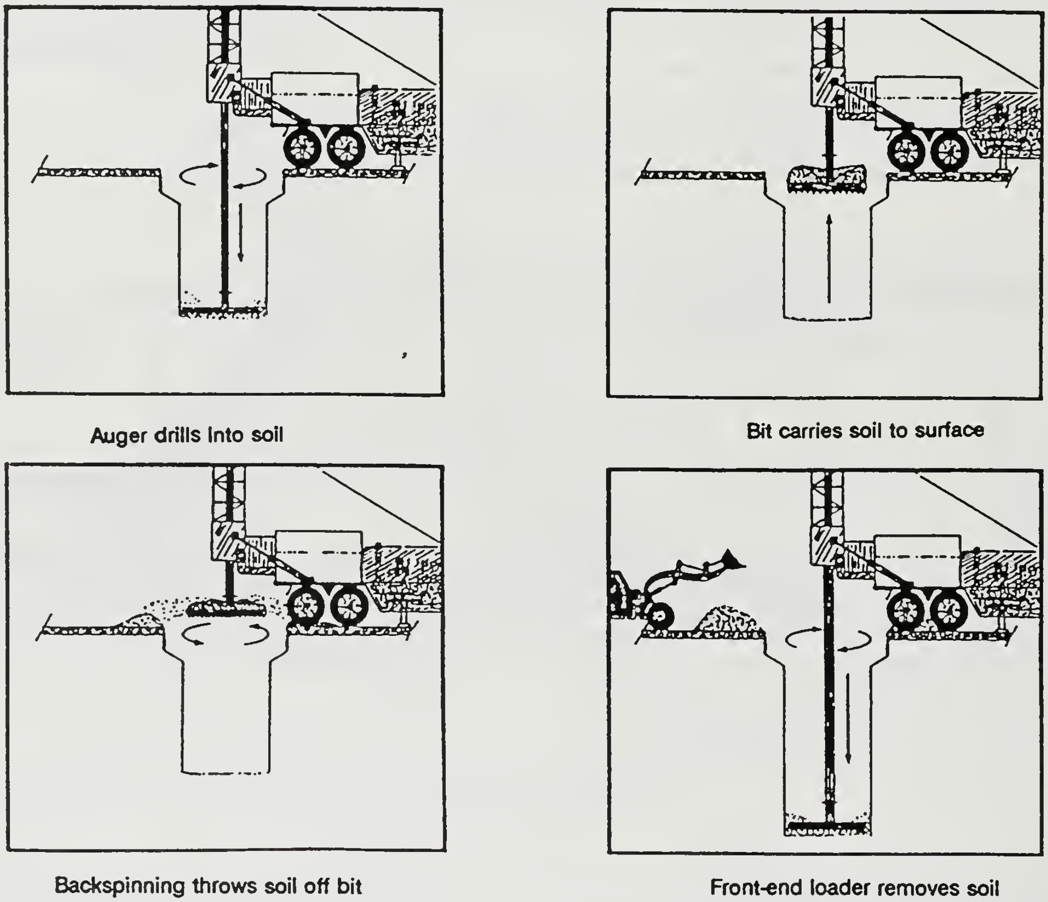
A drift mine 200 feet beneath the Baltic Sea is used for radioactive waste disposal in Sweden. Germany and Switzerland are investigating the drift mine method, and Belgium and France are exploring the use of shaft mines.

(5) Borehole or Augered Hole Disposal

Borehole or augered hole technology describes a hole sunk into the ground using an auger or other equipment that bores a hole to the desired width and depth. An alternate name for this type of methodology is "shaft disposal." Figure 13-E illustrates the borehole drilling sequence.

Constraints on the width and depth of the holes result from the drilling rig available. The larger the diameter of the hole, the larger the rig must be.

Figure 13-E
Borehole or Augered Hole



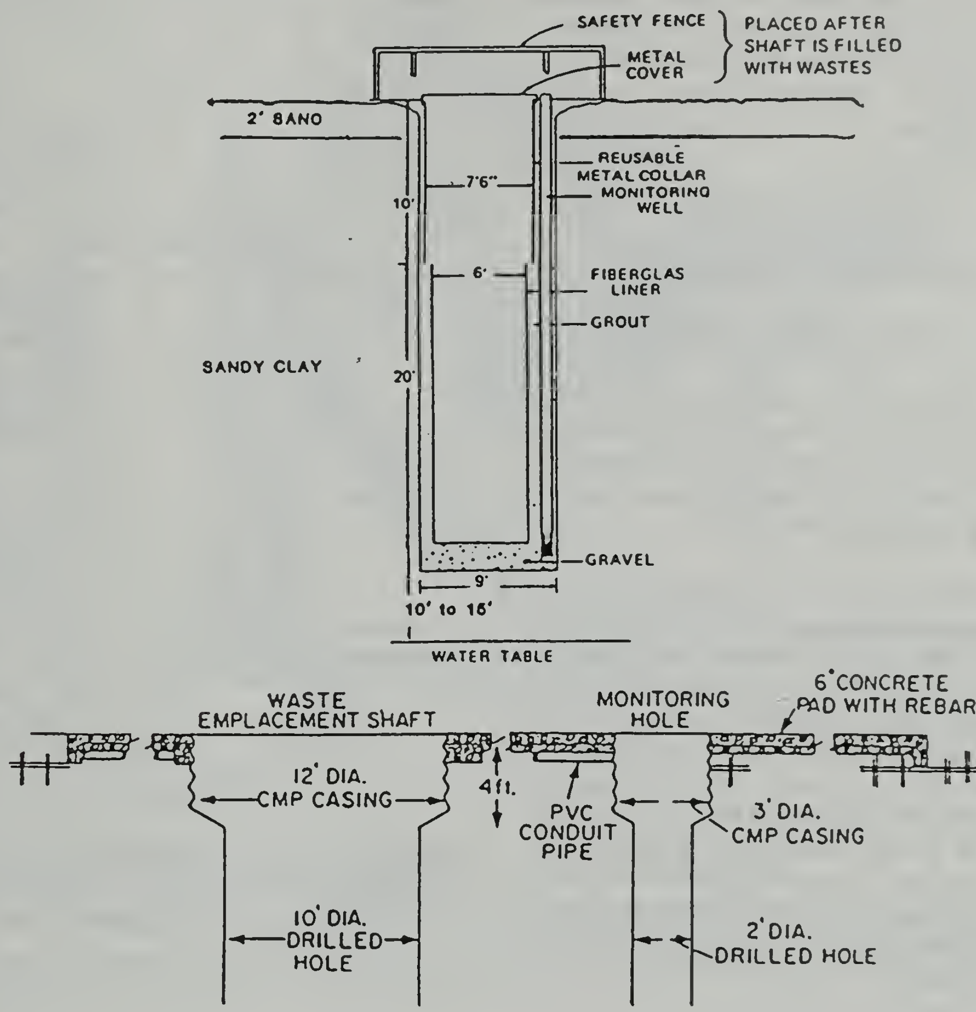
Source: Bennett, R.D. Alternative Methods for Disposal of Low-Level Radioactive Wastes; Task 2e: Technical Requirements for Shaft Disposal." NUREG/CR-3774, Vol. 5, U.S. Nuclear Regulatory Commission, Washington, DC, October, 1985.

The use of boreholes is quite limited in the United States. DOE has several experiments underway at some of its research laboratory sites. DOE installed some shafts in 1981 at the Nevada Test Site near Las Vegas, Nevada, as part of its Greater Confinement Disposal Test. In 1983 DOE began to place LLRW containing high specific activity into a central waste shaft surrounded by nine smaller holes containing monitoring and testing equipment. The waste disposal shaft is 10 feet in diameter and 120 feet deep. However, only 30 feet of the shaft was used for disposal. The bottom 20 feet and the top 70 feet were backfilled for this test.

A second Greater Confinement Disposal Test is being conducted at the Savannah River Plant in South Carolina. Boreholes nine feet in diameter and 32 feet deep are being used for the disposal of Class B LLRW. The bottom two feet of each hole are filled with gravel and a grout pad; a fiberglass liner, sealed at the bottom, is lowered into the hole to provide a barrier between the waste package and the soil.

A second liner, a 10-foot long steel collar, is then lowered into the hole inside the fiberglass. Most of the wastes are packed in 55-gallon drums and are lowered into the holes.

Figure 13-F
Greater Confinement Disposal Tests



Source: Bennett, R.D. Alternative Methods for Disposal of Low-Level Radioactive Wastes; Task 2e: Technical Requirements for Shaft Disposal." NUREG/CR-3774, Vol. 5, U.S. Nuclear Regulatory Commission, Washington, DC, October, 1985.

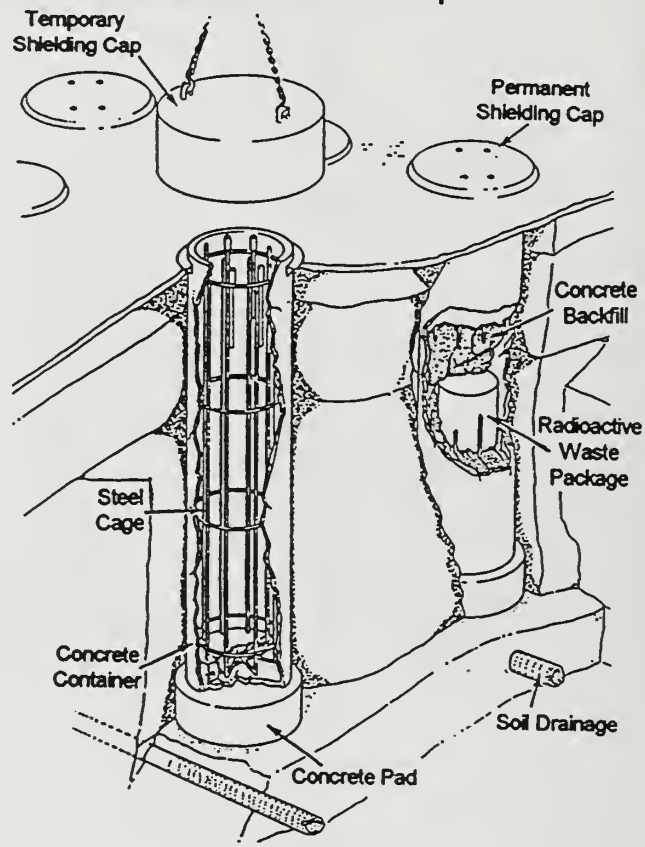
Figure 13-F illustrates the two Greater Confinement Disposal Test borehole methods.

DOE is also using boreholes at Oak Ridge National Laboratory in Tennessee for the storage of transuranic wastes. These holes are about three feet in diameter and an average of 21 feet deep. They sit on a formation of shale which separates the holes from the water table. Water sampling equipment and other instruments surround the holes. No migration of radionuclides from these augered holes has been detected.

Boreholes have also been used at Los Alamos National Laboratory, New Mexico, for the disposal of certain LLRW. The holes are about 2.5 feet in diameter and up to 65 feet deep. Some are lined in concrete.

Canada uses a variation of the borehole concept to store Ion exchange resins from its nuclear power plants. The Canadian "tileholes," as they are called, are large concrete pipes set vertically on concrete foundations. Water drainage can be monitored and controlled through a drainage system under the pipes. Figure 13-G is a schematic of the tilehole system.

Figure 13-G
Canadian "Tilehole" Disposal



Source: Bennett, R.D. Alternative Methods for Disposal of Low-Level Radioactive Wastes; Task 2e: Technical Requirements for Shaft Disposal." NUREG/CR-3774, Vol. 5, US Nuclear Regulatory Commission, Washington, DC, October, 1985.

Above-Ground Disposal Technologies

(6) Above-Ground Vaults

Above-ground vault technology has attracted the greatest interest in the past decade, and is the disposal method of choice for several of the new LLRW facilities under development around the United States.

Above-ground vault disposal means the waste is placed in an engineered structure located on the surface, roughly at the natural grade of the land. The structure, generally built of steel-reinforced concrete, has floors, walls, and ceilings around each "cell" used to isolate and dispose of the waste. The roof may be placed over each cell as it is filled, or it may be part of the original structure -- a "bank vault" type of building. Depending upon how access is gained to the cells, waste may be emplaced with assistance from overhead cranes or remote-controlled hoisting and moving devices within the facility.

No earthen cover is placed over the concrete vaults; they are intended to isolate the waste from the public and the environment. The floor of the vaults or drainage channels are constructed with a slight slope to drain into a monitoring system any water that may have entered the vaults. Each vault has a drainage system, sumps and standpipes to collect and monitor drainage continuously, if necessary, throughout the periods of operation, closure, and institutional control. Waste is segregated by Class A, B, and C for placement into the cells. As each cell is filled, the void spaces between waste packages are filled with sand or other material, and the cell is closed.

An illustration of one type of above-ground vault -- which has its ceilings added after each cell is loaded -- is shown in Figure 13-H.

(7) Above-Ground Vaults with Earthen Cover

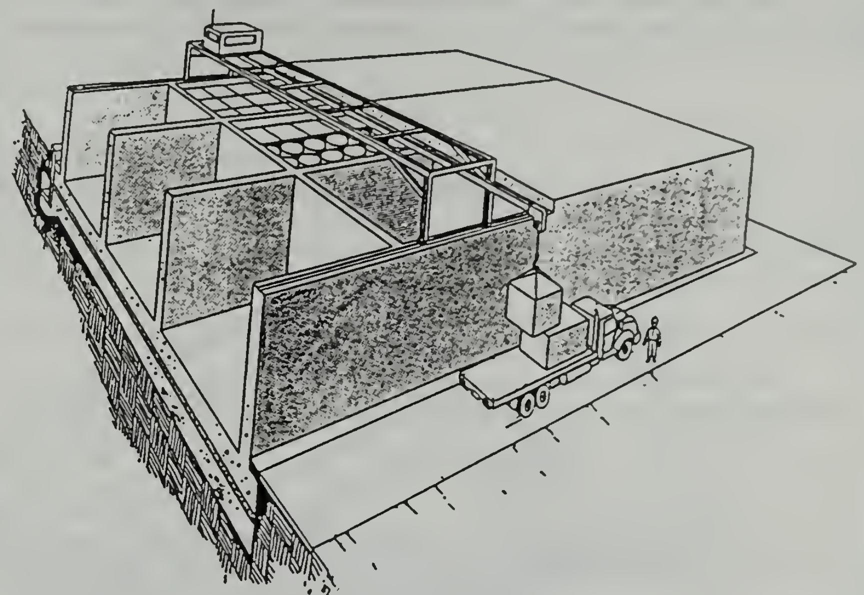
This disposal technology is similar to the above-ground vault method previously discussed, with one additional feature. A cover of various layers of earthen materials is placed over and around the structure

to protect the vault from environmental conditions (wind, rain, frost, etc.) that attack above-ground structures.

Such a cover, comprised of layers of sand or gravel, clay, stones, plaster, and soil, can be built to provide barriers to the infiltration of water, and drainage for any rainwater. It can also minimize the time in which waste would come into contact with infiltrating water if the top of the cement vault were damaged.

In addition, a cover over above-ground vaults provides an extra barrier to protect workers, the public, and any inadvertent intruders from radiation exposure.

Figure 13-H
Above-Ground Vault



Source: Rogers and Associates Engineering Corporation. Conceptual Design Report: Alternative Concepts for Low-Level Radioactive Waste Disposal. DOE/LLW-60T, EG&G Idaho, Inc., Idaho Falls, ID, June, 1987.

(8), (9) Above-Ground Modular Canisters

Another modification of the above-ground vault technology is the use of modular containers, or overpacks, to seal in waste entering the facility site. Waste packages are grouted into the steel reinforced concrete canisters, which are sealed once they are filled.

Canisters are then stacked on a concrete pad designed to drain water away from the canisters and into a drainage system for collection and monitoring.

Canisters may be uncovered or covered with earthen material. Covered canisters have been used for LLRW disposal at West Valley, New York, where a closed LLRW site is being cleaned up. Covered above-ground modular canister technology is also in experimental use at Oak Ridge National Laboratory in Tennessee.

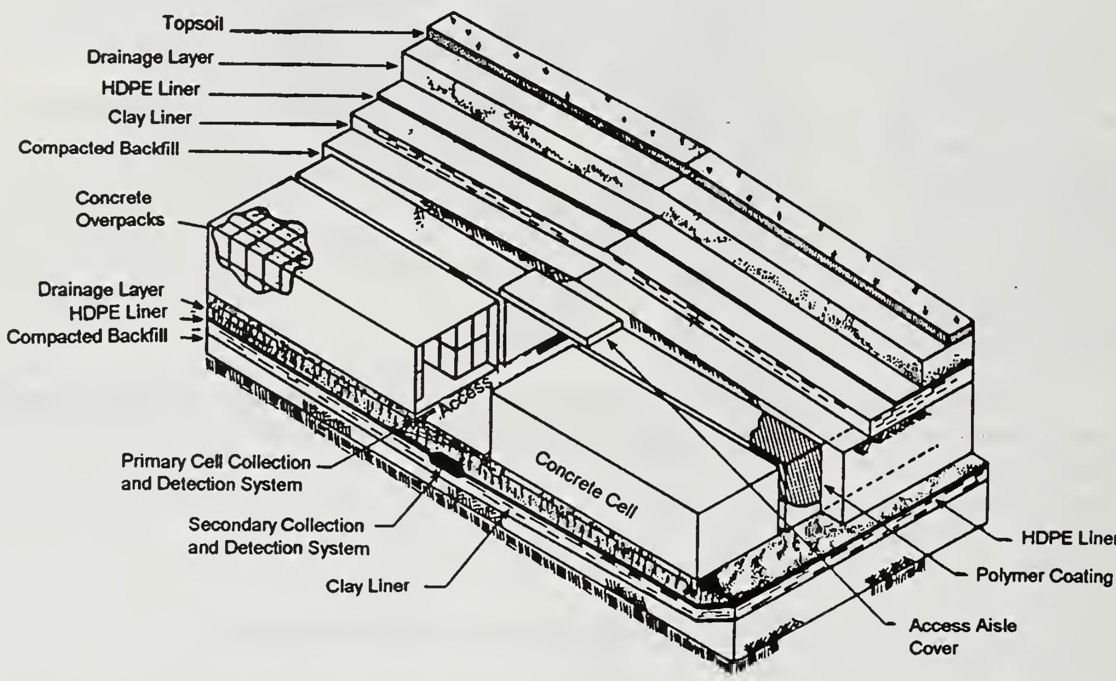
Technology Combinations

New designs for LLRW disposal are incorporating more than one technology to provide extra engineered barriers for protection and sophisticated waste and water monitoring technology while the LLRW within the waste packages decays over time. Disposal facility designs in North Carolina, Nebraska, Illinois, and Pennsylvania are planning combinations of above-ground technologies in their state-of-the-art facilities.

(10), (11) Above-Ground Vaults with Modular Canisters or Overpacks

One such "technology combination" Incorporates two above-ground methods Into its design. It utilizes concrete overpacks or modular canisters placed into above-ground vaults to provide two engineered barriers within the facility design. An illustration of this method is shown In Figure 13-I.

Figure 13-I
Above-Ground Vault with Concrete Overpacks



Source: Anderson, R.T., Chem-Nuclear Systems, Inc. "Concrete Overpack: Utilization as an Engineered Barrier for Low-Level Radioactive Waste Disposal." Paper presented to the Host State Technical Coordinating Committee, St. Louis, MO, Jan. 8, 1991.

A variation of this method would be earth-mounded above-ground vaults with canisters or overpacks.

Another possible mixture of technologies would be the use of LLRW disposal methods that incorporate both above- and below-ground concepts. This combination of technologies has evolved over time, beginning with the construction of underground bomb shelters in the 1940s to provide protection from surface explosions and radiation. Structures using below-ground features such as trenches and vaults and above-ground features such as canisters, vaults, and earth mounds have been designed and used for several decades as storage containment areas by many industrial users of radioactive materials.

Unacceptable Technologies

Technologies other than the 11 described above are available for LLRW disposal. However, they

could not meet the retrievability requirement of Chapter 111H, and are therefore not included in this analysis. Some of the unacceptable technologies include:

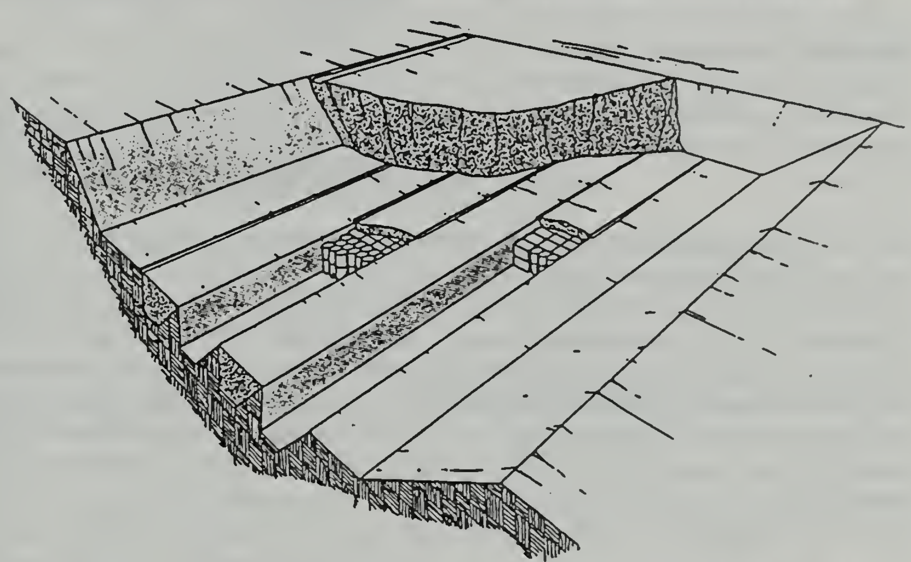
Hydrofracture is a method in which high pressure water is injected into shale deposits at depths 600 to 1000 feet below the surface, causing the shale to fracture. Liquid radioactive waste is mixed with a cement and clay grout, and injected into the fractured shale, where it is presumed to solidify in place. This method is used at Oak Ridge National Laboratory for the disposal of liquid LLRW.

Hydrofracture is a disposal method that depends upon the site's natural characteristics as the primary barrier for waste isolation. Even though it is not a "shallow" burial system, it still fits the general definition of disposal technologies prohibited because they rely on the "site's natural characteristics as the primary barrier for isolation of the waste." [Chapter 111H, section 1] In addition, it is not suitable for most LLRW, which is more solid than liquid, and waste could not be retrieved using this disposal technology.

Intermediate Depth Disposal utilizes the same excavated trench disposal system as in shallow land burial, but buries the Class B and C waste at twice the depth of disposal used in shallow land burial. Class B and C wastes are covered with a minimum of 33 feet of earth, while Class A wastes are placed in the shallower trenches used in the shallow land burial system.

Figure 13-J illustrates the Class B and C disposal trenches in an intermediate depth system.

Figure 13-J
Trenches for Class B and C Waste, Intermediate Depth Disposal



Source: Rogers and Associates Engineering Corporation. Conceptual Design Report: Alternative Concepts for Low-Level Radioactive Waste Disposal. DOE/LLW-60T, EG&G Idaho, Inc., Idaho Falls, ID, June, 1987.

Earth-Mounded Concrete Bunkers. The concept of using below-ground concrete monoliths for some waste and above-ground modular canisters covered by earth for other waste was developed by the French government to allow waste segregation based on its level of radioactivity. The French embed intermediate-level waste[23] containers into below-ground concrete monoliths, and LLRW (or intermediate-level wastes in modular canisters) are placed above-ground in earthen mounds over the concrete vaults. A modification of this concept for LLRW only would have the Class B and C waste placed below-ground in monoliths, and the Class A waste above-ground, and covered by the earthen mound.

An illustration of the earth-mounded concrete bunker technology is shown in Figure 13-K.

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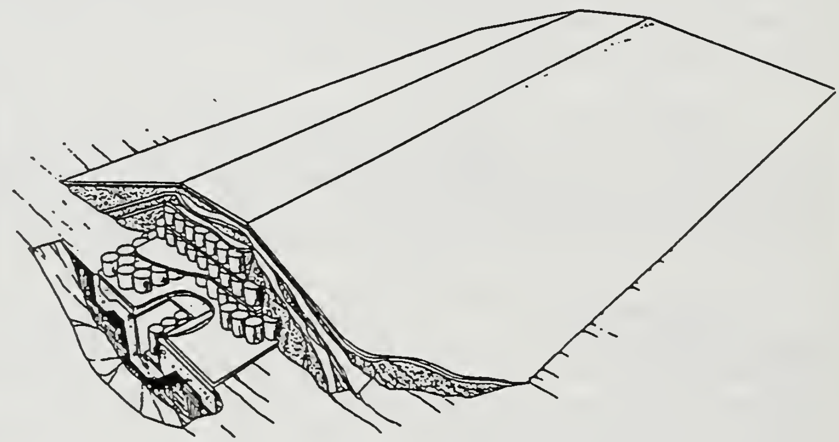
[23] The term "intermediate level" wastes refers to Greater than Class C (GTCC) wastes.

When the last layer of waste has been lowered into the below-ground compartment, reinforcing steel is placed on top and the compartment is completely backfilled with concrete to create a concrete monolith encapsulating the waste. Spaces between each monolith are also filled with waste, backfilled and covered with concrete. Then the monoliths are waterproofed with a layer of asphalt.

Mounds are subsequently constructed on top of the buried vaults using Class A wastes in concrete canisters. Structural stability for the mounds is provided by the canisters.

Figure 13-K
Earth-Mounded Concrete Bunker



Source: Rogers and Associates Engineering Corporation. Conceptual Design Report: Alternative Concepts for Low-Level Radioactive Waste Disposal. DOE/LLW-60T, EG&G Idaho, Inc., Idaho Falls, ID, June, 1987.

The earth-mounded concrete bunker system has proven quite successful in France, and one site at Centre de la Manche has initiated a 200-300 year monitoring period of its completed (and closed) disposal units. This technology is unacceptable for Massachusetts, however, because it does not allow retrieval of waste packages, if such a necessity were to arise. Certainly the Class B and C waste containers could be extricated from their concrete monoliths by digging and chipping away the concrete, but such activity would not be conducive to the retention of waste package integrity, and would likely result in releases of radioactivity. This technology, therefore, does not allow retrievability.

13.6 Analysis of Disposal Technologies and Practices

As in the previous two chapters analyzing treatment and storage technologies and practices, the analysis of current and developing LLRW disposal technologies and practices, required by section 12(b)(2) of Chapter 111H, must include an evaluation of:

(1) the potential public health, safety, and environmental impacts of disposal technologies and practices;

(2) their climatic, geologic, hydrogeologic, or other requirements;

(3) their suitability for the LLRW managed within Massachusetts;

(4) their cost-effectiveness;

(5) recommendations for regulatory or other actions to improve the safety or efficiency of disposal technologies and practices; and

(6) recommendations for regulatory or other actions to ensure that property values are maintained in the vicinity of any disposal facility.

This section analyzes each disposal technology category (below-grade, above-grade and the combinations) as they relate to the subject of items (1), (2), (3) and (5), above. An analysis of cost-effectiveness of all types of retrievable disposal facility technologies is contained at the end of this chapter. The subject of (6) above is discussed in Chapter 17.

(1) Potential Health, Safety and Environmental Impacts

Based on facility design, the manner of operation, the types and forms of LLRW accepted, and numerous other factors, there may be no adverse health, safety or environmental impacts from the technologies described in the previous section. The fact that packages of waste could, if damaged, release radiation and cause exposures does not necessarily imply a health impact as a result.

However, for purposes of analyzing potential health, safety and environmental impacts, the Rogers Conceptual Design Report postulates a number of worst-case factors that could lead to negative effects. These are reviewed for certain types of below-grade and above-grade technologies.

Below-Grade Disposal Facility Technologies

The health, safety and environmental impacts of below-grade disposal technologies vary with the degree of engineered structures added to the basic below-ground method of shallow land burial. A summary of these impacts follows.

Shallow-Land Burial. The Rogers and Associates Conceptual Design Report predicts a number of potentially adverse health, safety, and environmental impacts associated with the use of the shallow land burial methodology, including:

- Doses of radiation to the general public during the early years following closure of the site "are dominated by radionuclides from the surface contamination which is transported off site by erosion, surface water and atmospheric transport."

- Waste packages "are assumed to fail progressively over years 20 through 70 after disposal."

- Class A trenches are assumed to sink through the next couple hundred years, "during which time 20% of the earth cover is assumed to fail," allowing more water to come in contact with the waste, and more movement of radionuclides.

- Rather than the Class B and C trenches subsiding, the materials used to solidify these wastes are assumed to fail, doubling the nuclide release between years 300 and 500.

- Doses to workers range from a high of six person-rem[24] per year for employees off-loading waste containers and placing them in trenches, to a low of 0.3 person-rem per year to the

[24] A "person-rem" measures the total radiation dose received by a whole population. Additional information on measures of radiation dose and exposure is contained in Chapter 3.

workers who transport the shipments on site.

The analysis in the Conceptual Design Report predicts that the maximum yearly radiation dose to a member of the general public who lives on a farm adjacent to a shallow land burial site would occur 560 years after the facility had closed, but would still be less than the maximum dose criteria set by the NRC (25 millirem/year whole body dose and 75 millirem/year to the thyroid). The Rogers study states:

> "As container failure progresses, the low initial doses from surface contamination are soon dominated by groundwater doses. The dose increases slightly as the waste solidification agent degrades. The dose reaches a maximum at year 560, then slowly declines as the waste inventory is depleted through radioactive decay and leaching."

As has been noted, in Massachusetts, shallow land burial is expressly prohibited by state law. Even if it were an allowable disposal method, the requirement in Chapter 111H that waste disposal must be retrievable eliminates shallow land burial as an option. Because waste packages are likely to degrade over time, and there is no additional barrier to contain the waste in the trenches, the waste cannot reasonably be retrieved if some portions of it have leached into the ground below and adjacent to the trenches. Technically speaking, the entire area around the trenches could be dug up, but that is not the intent of the "retrievability" requirement.

Below-Ground Modular Concrete Canister Disposal. The concrete canister acts as an additional barrier to the release of radionuclides in the waste over the shallow land burial methodology. Because of the assumptions Rogers and Associates made regarding concrete longevity, the Rogers report concludes that the canisters would not degrade for 200 years, but predicts that some radionuclides would be diffused through the canister walls about 30 years after the site is closed (i.e., 60 years from the start of disposal operations). The study also predicts that the release of more radioactivity would continue through the remaining 140-year lifetime of the canisters.

The Rogers study also concludes that the peak dose to the public living on a farm adjacent to the site would be approximately 15% lower than the study projected for shallow land burial. The peak dose would occur about 560 years after the site was closed, and be caused by ingestion of radionuclides through groundwater.

While the canisters have a positive impact of delaying and reducing the release of radioactive materials into the environment, and thereby lowering exposure to the public in comparison to the shallow land burial technology, they have a negative impact with respect to radiation exposure to facility workers at the site. According to the Rogers study, the placement of high-specific activity waste into the canisters, followed by the insertion of canister covers, would double the annual worker exposure rate (to 16 person-rems per year) over that of shallow land burial.

Concrete canisters also enhance the stability of the disposed waste over that which is disposed through shallow land burial. Class B and Class C waste stability requirements of 10 CFR Part 61 must still be met by treating the waste form or by the waste packages that would be inserted into the canisters. The extra barrier surrounding the waste packages provided by the concrete canisters helps to retain stability in the disposal unit.

Below-Ground Vaults. The Rogers study predicts that no radionuclides would be released from below-ground vaults prior to the year 500, when Rogers assumed the structure would fail due to concrete degradation. This study also assumes that 20% of the cover for the Class A cap would fail at year 500. In addition, Rogers postulates that the materials used to solidify Class B and C waste would fail over years 300 through 500, thereby enabling radionuclides to leach out of the vaults when they fail at year 500.

The Rogers study calculated the maximum yearly dose of radiation to (1) the general public who is assumed to live on a farm adjacent to the below-ground vault site, (2) an inadvertent intruder who farms the site, and (3) an intruder who builds a home on the site. Table 13-2 illustrates the maximum yearly dose to the whole body and the thyroid, and reveals the dominant pathway for exposure and the dominant radionuclides causing the exposure for certain below-grade technologies.

Table 13-2
Radionuclide Dose Summary of Certain Below-Grade Disposal Technologies

Disposal Technology	Year of maximum dose	Maximum whole body dose (NRC limit 25 mrem/yr)	Maximum thyroid dose (NRC limit: 75 mrem/yr)	Dominant Pathway	Dominant Radionuclides
Shallow Land Burial					
Public Exposure (Adjacent Farm)	560	7.5	46	Ingestion	I-129 C-14
Intruder Exposure (Agriculture)	560	7.5	46	Ingestion	I-129
Intruder Exposure (Construction)	100	4.1	–[a]	Direct Radiation	Cs-137
Below-Ground Modular Concrete Canister					
Public Exposure (Adjacent Farm)	560	6.6	40	Ingestion	I-129
Intruder Exposure (Agriculture)	570	6.7	40	Ingestion	I-129 C-14
Intruder Exposure (Construction)	500	0.03	–[a]	Inhalation	Am-241
Below-Ground Vault					
Public Exposure (Adjacent Farm)	570	4.1	39	Ingestion	I-129
Intruder Exposure (Agriculture)	570	4.1	39	Ingestion	I-129 C-14
Intruder Exposure (Construction)	560	0.01	–[a]	Inhalation	Am-241

[a] The study does not calculate this dose.

Source: Adapted from Rogers and Associates Engineering Corporation. Conceptual Design Report: Alternative Concepts for Low-Level Radioactive Waste Disposal. DOE/LLW-60T, EG&G Idaho, Inc., Idaho Falls, ID, June, 1987.

The major impact of the below-ground vault technology, according to the Rogers report, is a potential increase in radiation exposure to workers at the site who must cast the permanent concrete vault covers in place by hand. The Rogers study estimates that this requirement could provide a yearly dose of 10 person-rem.

There are some potential advantages inherent in the below-ground vault technology. They include:

- Water movement inside and around the vaults can be continuously monitored and sampled.

- Waste can be removed from a vault, repackaged, and replaced in a newly-constructed vault for several hundred years of additional protection while radionuclides remaining in the waste continue to decay.

- Electronic systems can be installed to monitor waste package integrity.

- Below-ground vaults are visually less obtrusive then above-ground structures.

- The vault provides an additional barrier to prevent water infiltration into the waste, and to prevent human intrusion.

- Gases and liquids cannot easily escape from the vault due to its structure and earth cover. The movement of radiation to the surface is impeded by the engineered roof and earth cover.

- The vault provides additional structural stability around the waste.

There are also some potential disadvantages. They include:

- Vaults must be protected from flooding conditions during construction and operation.

- Below-ground vaults cannot be externally inspected or monitored visually.

- Depending upon the means of access to the vaults (e.g., from the top or the side), the use of remote waste package handling equipment could be limited, thus requiring site workers to be exposed to higher radiation levels.

Mined Cavity. Mined cavities can frequently offer favorable impacts on health, safety, and environmental considerations. For example, an important aspect of LLRW disposal is to ensure that radiation is shielded from the public. If waste is placed in shallow trenches or other disposal units near or above the surface, barriers to prevent radiation exposure are a critical element of the disposal system.

For mined cavity LLRW disposal, however, the rocks that form the roof and walls of the mine chamber provide an extremely protective natural barrier. The rock formation has been present for millions of years, and can therefore provide assurances of hundreds of years of stability and protection from surface radiation exposure.

Mines are damaged less from earthquakes and other seismic activities than surface facilities. This is due to the fact that they respond to the ground, itself, while surface facilities amplify the ground motion.

Certain environmental concerns such as the surface geological and weather characteristics of a potential site are extremely important in evaluating potential disposal sites for near-surface or above-ground disposal. However, these criteria have little or no impact on the mined cavity technology.

However, expertise in structural geology is fundamentally important to developing a mined cavity site. If drilling and blasting is used to form the mine cavity, it must be accomplished with skill by experienced professionals who can avoid weakening the surrounding rock structure. Less damaging excavating and tunneling methods should be used. Mining accidents which are not related to LLRW disposal can occur, and caution should be taken to prevent them. On this point, a 1986 NRC study asserts that the likelihood of injury occurring due to a mining-related accident is "probably greater" than from a

radioactivity accident, and requires that emergency procedures be in place for both accident types.[25]

The regulatory requirement for environmental monitoring can be more difficult to accomplish with the mined cavity technology than with other disposal technology, but it is not technologically impossible. Monitoring equipment installed on the surface is considered by many who have studied this problem to be preferable to monitoring instruments left inside the mine itself.[26] Problems cited include questions about data reliability and the inability to make system repairs.

Borehole or Augered Hole. According to the literature available on the use of boreholes for LLRW disposal, surface water and groundwater are the most significant pathways for potential long-term releases of radiation to the general public. Evaluations of any potential site for boreholes, therefore, must be precise in the areas of geology, hydrology, and climatology. In addition, boreholes that emplace the waste below the water table will require a different design than boreholes above the water table.

Other potential environmental impacts relate to soils that are liquefiable, corrosive or dispersive, and areas where land subsidence is a problem. All of these concerns were discussed briefly in the earlier section on below-ground vaults, and apply to the borehole technology as well.

Because the waste in a borehole could not easily be visually inspected to evaluate its susceptibility to leach, corrode, or cause other potential environmental, health, and safety damage, the use of this technology must rely heavily on active monitoring systems installed around the boreholes. The reliability of those systems would be extremely important. Boreholes combined with retrievable modular concrete canisters would allow more direct monitoring.

Above-Grade Disposal Facility Technologies

The use of above-ground technologies rather than shallow land burial for LLRW disposal can have positive effects on public health, safety, and on the environment. Above-ground structures of steel-reinforced concrete are more capable of isolating waste than the natural soil barrier of trench walls in shallow land burial. The waste inside the vaults or modular canisters is separated from the air, water, and ground for as long as the integrity of the structures remain. Water monitoring systems and other instrumentation alerts the facility operator to the presence of any water that could damage waste packages or serve as a pathway to the environment, or any chemical reactions that could degrade waste containers, before waste or radioactivity has entered the environment, as occurs in shallow land burial technology.

In addition to the mechanical monitoring equipment, certain above-ground structures can be visually inspected more readily during the periods of operation, closure, and institutional control. The engineering and installation of waste monitoring systems are less complicated than with below-ground technologies, thereby facilitating the retrieval, repackaging, and re-emplacement of waste containers, if necessary.

Potential negative effects include the unknown lifetime of reinforced concrete. Exposure of concrete structures to rain, wind, cold, and acid rain can speed the concrete's degradation over that of structures protected with earth and plastic covers. All above-ground structures not covered with earthen or engineered

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[25] McAneny, C.C. (Geotechnical Laboratory, US Army Engineer Waterways Experiment Station, Vicksburg, MS). Alternative Methods for Disposal of Low-Level Radioactive Wastes, Task 2d: Technical Requirements for Mined Cavity Disposal. NUREG/CR-3774, Vol. 6. U.S. Nuclear Regulatory Commission, Washington, DC, October, 1986.

[26] U.S. Department of Energy. National Waste Terminal Storage Program Criteria for Mined Geologic Disposal of Nuclear Waste. DOE/NWTS-33(3). Washington, DC, July, 1982.

covers may require active maintenance over the institutional control period due to their exposure to the elements. This requirement may be incompatible with the NRC requirement to minimize active maintenance. However, the Rogers study indicates that features can be designed into the facility to minimize potential environmental, health, and safety disadvantages. For example, an above-ground vault disposal unit could be designed to meet nuclear power plant containment structure requirements for earthquake resistance and quality control.

Above-Ground Vaults. The dose summary from the Rogers Conceptual Design Report is shown in Table 13-3.

Table 13-3
Radionuclide Dose Summary for Above-Ground Vaults

Exposure scenarios	Years of maximum dose	Maximum whole body dose (NRC limit: 25mrem/yr)	Maximum thyroid dose (NRC limit: 75 mrem/yr)	Dominant Pathway	Dominant Radionuclides
Public Exposure (Adjacent Farm)	580	34	330	Ingestion	I-129
Intruder Exposure (Agriculture)	580	7.9	40	Ingestion	I-129 C-14
Intruder Exposure (Construction)	500	0.4	–[a]	Inhalation	Am-241

[a] The study does not calculate this dose.

Source: Rogers and Associates Engineering Corporation. Conceptual Design Report: Alternative Concepts for Low-Level Radioactive Waste Disposal. DOE/LLW-60T, EG&G Idaho, Inc., Idaho Falls, ID, June, 1987.

This analysis assumed that the concrete vaults would remain intact for 500 years. After that time, based on the Rogers and Associates assumption about concrete integrity, the vault walls would slump and expose some waste, since no earthen cover surrounded the vaults. Movement of radioactivity into the environment would occur based on the distribution of the radionuclides in the waste, Rogers surmised.

The Rogers study also assumed that 10% of the water that contacts the waste (after 500 years) is surface water that will flow across the ground to the neighboring farm where a member of the public resides. The study also assumed that 90% of the radioactively-contaminated water would soak into the ground, towards the water table.

As far as protection from the inadvertent intruder who occupies the site for farming or home construction purposes, the Rogers study also assessed the above-ground vault technology's ability to meet NRC dose limits. The study concluded that the inadvertent intruder would be deterred by the vault structures, even after the cement vaults were no longer able to protect the waste inside from water intrusion.

A comparison of the calculations of radiation dosage potentially affecting the public, which are contained in the Rogers study, appear in Table 13-4. They show that the potential dose to individuals living on a farm adjacent to the above-ground vault disposal facility would occur later in the life of the facility, but would amount to greater amounts of radiation contacting farm residents.

Above-Ground Vaults with Modular Canisters. The discussion of potential public health, safety, and

Table 13-4 Comparison of Public (Adjacent Farm) Potential Dose for Four Disposal Technologies					
	Shallow Land Burial	Below-Ground Modular Concrete Canister	Below-Ground Vaults	Above-Ground Vaults	NRC dose limits
Year of maximum dose	560	560	570	580	
Maximum whole body dose (mrem/yr)	7.5	6.6	4.1	34	25
Maximum thyroid dose (mrem/yr)	46	40	39	330	75
Dominant Pathway	Ingestion	Ingestion	Ingestion	Ingestion	
Dominant Radionuclides	I-129 C-14	I-129	I-129	I-129	

Source: Rogers and Associates Engineering Corporation. Conceptual Design Report: Alternative Concepts for Low-Level Radioactive Waste Disposal. DOE/LLW-60T, EG&G Idaho, Inc., Idaho Falls, ID, June, 1987.

environmental advantages and disadvantages in the previous section generally applies to this technology as well, and will not be repeated here. No studies are available, however, to estimate the maximum annual dose to a member of the public or to an inadvertent intruder, and the Rogers estimates for above-grade technologies should not be assumed to apply, since the above-ground vaults with modular canisters technology has an extra engineered barrier over the above-ground vault technology. Concerns over concrete vault degradation are lessened by the second engineered barrier, the canisters inside.

Additional environmental advantages to this double-engineered barrier system include:

- longer-lasting radiation shielding;
- long-term structural integrity (300-500 years);
- long-term inadvertent intruder protection;
- enhanced retrievability of the waste;
- minimizes compressive structural loading; and
- minimizes the possibility of long-term water contact with the waste.

"Enhanced" Earth-Mounded Above-Ground Vaults with Steel Boxes. A variation of the two-barrier above-ground vaults with concrete canisters is the use of carbon steel boxes instead of canisters, and the covering of all vaults with an impervious membrane and an earthen mound.[27] In a study of this technology, conducted by Rogers and Associates in 1989 to update the earlier Conceptual Design Report,

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[27] Shuman, R., Chau, N. and Jennrich, E.A. (Rogers and Associates) Long-Term Structural and Radiological Performance Assessment for an Enhanced Abovegrade Earth-Mounded Concrete Vault. DOE/LLW-78T, U.S. Department of Energy Defense Low-Level Waste Management Program, Idaho Falls, ID, December, 1989.

the performance of the "enhanced" above-ground facility was simulated for a period of 10,000 years following the facility closure, and the same three exposure scenarios were used that Rogers analyzed in the earlier study: (1) public (adjacent farmer), (2) inadvertent intruder (agriculture), and (3) inadvertent intruder (construction).

Two values pertaining to possible water infiltration through the earthen cover were factored into the mathematical model used to calculate the performance of this multi-technology disposal system.[28] The analysis concluded that these earth-mounded above-ground vaults have an effective infiltration barrier for just over 5,000 years, regardless of the cover system placed over the vaults.

What is striking about this second Rogers study are the projections of minute radionuclide dosage that could occur, but only after a minimum of 5,000 years. The potential dose summaries for both the public and intruder scenarios are shown in Table 13-5. The maximum calculated dose to a member of the public is estimated to occur 5,249 years after the site is closed, and the dose is 30,000 times less than the NRC's 25 millirem per year performance objective. The Rogers study assumes this dose is a result of the ingestion of Carbon-14 for the facility using the cover system which allows 2.8 centimeters per year of water to infiltrate the cover. For the 0.1 centimeter-per-year cover, the analysis showed no dose whatsoever to the public throughout a 10,000-year period.

In the case of the inadvertent intruder, the maximum dose never approaches the exposure limit of 500 millirem per year or the DOE performance objective of 100 millirem per year. The maximum dose occurs 5,204 years after site closure, and is 70,000 times less than the DOE performance objective.

Rogers and Associates concludes that in regards to the enhanced above-grade earth-mounded concrete vault:

> "it is clear that the previously calculated performance of the above-ground vault facility (Conceptual Design Report) cannot be construed as applicable to all above-grade disposal strategies. On the contrary, the analysis of the above-grade earth-mounded concrete vault disposal facility provides strong evidence of the viability of this mode of LLRW disposal."

A design similar in concept to the second Rogers model has been developed by US Ecology for the Central Interstate Compact disposal facility in Nebraska. The multi-barrier technology uses the basic above-ground vault concept, but places the vaults inside a reinforced concrete warehouse-type building. Waste enters the building through bays and is carried by remote crane to a cell for disposal. As the cells are filled, they are closed up inside the warehouse building.

(2) Climatic, Geologic, Hydrogeologic, and Other Requirements

All of the federal and state siting criteria listed earlier in this chapter, which must be applied in identifying potential sites for LLRW disposal facilities, would have to be met for whatever type of disposal technology is chosen by a site community. No LLRW disposal technology can be placed over a drinking water supply, into a wetland, on land in a 100-year flood plain, or in a coastal high-hazard area, for example, just because it contains a concrete vault or canister barrier or some other protective, engineered features designed to keep all LLRW away from the environment.

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[28] The study analyzed a cover system that allowed 0.1 centimeter per year of water to infiltrate into the cover, which was based on tests conducted by the French Government at its above-ground facility at Centre de la Manche, the French LLRW disposal site. The second value of waste infiltration analyzed was a more permeable cover system allowing 2.8 centimeters per year of water infiltration.

Table 13-5 Radionuclide Dose Summary for "Enhanced" Above-Ground Earth-Mounded Vault		
Exposure Scenario	Dose Summary	
	2.8 cm/yr. Percolation Rate	0.1 cm/yr. Percolation Rate
Public Exposure (Adjacent Farm)		
• Year of Maximum Dose	5,249	–[a]
• Max. Effective Dose Equivalent[b] (mrem/yr.)	0.00074	0
• Dominant Pathway	Ingestion	–[a]
• Dominant Radionuclide	C-14	–[a]
Intruder Exposure (Agriculture)		
• Year of Maximum Dose	5,204	5,008
• Max. Effective Dose Equivalent (mrem/yr.)	0.0013	0.00058
• Dominant Pathway	Ingestion	Dust Inhalation
• Dominant Radionuclide	C-14	U-238
Intruder Exposure (Construction)		
• Year of Maximum Dose	5,008	5,008
• Max. Effective Dose Equivalent (mrem/yr)	.00017	.00017
• Dominant Pathway	Dust Inhalation	Dust Inhalation
• Dominant Radionuclide	U-238	U-238

[a] The year of maximum dose occurs after 10,000 years. During that period, the dose equivalent is 0; there is no dominant pathway or radionuclide.
[b] The "effective dose equivalent" is the sum of the products of the "dose equivalent" to the organ or tissue and the weighting factors applicable to each body organ that may receive radiation. This term and others related to it are discussed in Chapter 3 of this volume.

Source: Rogers and Associates Engineering Corporation. Long-Term Structural and Radiological Performance Assessment for an Enhanced Abovegrade Earth-Mounded Concrete Vault. DOE/LLW-78T, U.S. Department of Energy, Idaho Falls, ID, December, 1989.

Below-Grade Disposal Facility Technologies

Below-Ground Vaults. Below-ground disposal technologies rely heavily on favorable geologic and hydrogeologic conditions to ensure that waste that may by accident escape from the engineered barrier will not automatically contaminate groundwater. Climate is also an important consideration in siting any below-grade technology. Climatological and meteorological data should be collected to evaluate the frequency of unusual climate conditions. The NRC's Branch Technical Position on site suitability recommends that a meteorological station be established on site and operated for at least one year during site characterization to collect site-specific data. It is also recommended that the monitoring equipment remain at the site to continually collect data.

Because the most significant pathways for potential long-term releases of radionuclides to the public are surface and groundwater, these hydrological conditions must receive proper characterization at a potential disposal site. The surface and subsurface hydrology of the site should be modeled, and sampling done throughout design, construction, operation, closure, and institutional control. Evaluating groundwater pathways is one of the most crucial and costly tests for site suitability.

An analysis of below-ground vaults completed for the NRC in 1985 by the Geotechnical Laboratory of the U.S. Army Engineer Waterways Experiment Station recommends the inclusion of other criteria for determining below-ground site suitability. They include determining the existence and potential adverse impacts of:

- dispersive soil deposits, which could increase the rate of erosion and collapse at the surface;
- liquefiable soils that change soil from solid to a liquified state and result in a loss of the soils' strength;
- corrosive soils from metallic concentrations, which can deteriorate concrete vault walls, floors, roofs, and waste packages;
- clay soils, which can expand due to changes in moisture content and cause buckling, warping and other distortion of the vault structure;
- underground tunnels or caves caused by slowly moving groundwater dissolving certain types of rock , which can cause the earth overlying these formations (but underneath the below-ground vaults) to collapse and affect the vault structure; and
- sinking or collapse of the land.

Mined cavity. A very important environmental characteristic to consider in connection with mined cavities is the water table. Most mines would be constructed below the water table. In humid regions, like Massachusetts, where the water table is generally close to the surface, a shaft or slope mine may penetrate the water table. A drift mine bored into the side of a hill or mountain could be located above the regional water table, which is controlled by the network of streams in the region. However, it could also be beneath local, elevated water tables in the hill.

The impact of flooding on mine development and operation is a potentially serious one, and flooding incidents have been documented. Water in the mine cavity can soak the wastes, allowing radionuclides to leach into moving ground water and into other parts of the environment.

A number of additional environmental requirements were identified in a 1986 NRC study[29] of mined cavity disposal for LLRW. They are briefly summarized here:

- The surface openings to any mined cavity should be sited or engineered (or both) so that surface floodwaters cannot enter the mine.
- A natural hydrologic barrier should be identified around the entire mine to ensure that fractures of rock will not cause groundwater to leak into the cavity where waste is deposited.
- A buffer zone around the mine should not be merely the land adjacent to the mine entrance, but

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[29] Op cit., McAneny.

should also include the subsurface rock area around the mine cavity to protect the facility from accidental disturbances, such as other exploratory activities.

- The mine must be dry to be used for LLRW disposal. "Any mine that generates enough water to require pumping would be unacceptable as an LLRW site."[30]

Above-Ground Disposal Facility Technologies

Providing for changes in climate conditions is an important requirement in designing any above-ground disposal facility, especially those such as above-ground vaults and above-ground modular canisters that employ no other cover for protection (earth or engineered). According to an NRC report, "exposure to the weather is the single greatest natural hazard to an above-ground vault, regardless of the quality of engineering design and construction."[31] All climatic conditions must be evaluated in developing the above-ground vault and above-ground modular canister designs. Concrete will be attacked by extremes of weather (freeze-thaw) and by acid rain and wind. Vault/canister components made of metal will corrode; components made of plastic will degrade chemically from sunlight.

Surface waste and groundwater are potentially the most serious pathways for the release of radionuclides to the public. To ensure proper hydrological characterization of the site for an above-ground facility, both site-specific and regional data on hydrological conditions need to be collected and analyzed.

(3) Suitability of LLRW Disposal Technologies for Massachusetts LLRW

The "suitability" or "appropriateness" of the various LLRW disposal technologies discussed in this chapter would, ultimately, be determined by the site community, if a disposal facility were ever sited in the Commonwealth.

Chapter 111H provides that the site community, not the Commonwealth, would make two very critical decisions in the siting process: (1) select the company it feels could best build and operate the facility, and (2) pick the technology to be utilized at the facility. [Chapter 111H, section 27]

Given those provisions, the questions of "suitability" should be left to a future site community, if siting ever is initiated. However, there are some basic issues relevant to the question of suitability, and they are mentioned briefly below.

Below-Ground Disposal Technologies

The hydrological conditions present in Massachusetts, such as the water table close to the surface in many parts of the state, would pose a challenge to the siting of any disposal facility using below-grade technologies. While this challenge could be an obstacle, environmental engineers believe it could be successfully overcome.

Below-ground modular concrete canister. Because the below-ground modular concrete canister disposal system requires the use of shallow trenches, the Commonwealth's geohydrology may pose a

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[30] Op cit., McAneny.

[31] Bennett, R.D. and Warriner, J.B., U.S. Army Engineer Waterways Experiment Station. Alternative Methods for Disposal of Low-Level Radioactive Wastes, NUREG/CR-3774, U.S. Nuclear Regulatory Commission, Washington, DC, October, 1985.

significant problem in identifying sites where the groundwater is below the trench depth. The use of this technology would, therefore, appear to be less suitable in Massachusetts than in other, more arid states.

Below-ground vaults. The relatively high water table in Massachusetts is also a serious siting obstacle for below-ground vaults. Detailed site characterization studies would have to show that a good distance existed between the bottom of the vaults and drainage area, and the top of the water table. Even then, with the geological changes that can occur over hundreds of years, the water table could rise, and expose groundwater to the base of the vaults.

Mined cavity. The mined cavity disposal technology could fall under the definition of "shallow land burial" in Chapter 111H, since that definition does not allude to disposal depth, but describes any disposal method "that relies on the site's natural characteristics as the primary barrier for isolation of the waste." A mined cavity that relied on the rock around it as the primary barrier for waste isolation would fall under the class of disposal technologies prohibited by Chapter 111H.

However, a mined cavity that incorporated vaults or other engineered structures into its design would be acceptable under the law's definition. Such a mined cavity operation would also allow retrieval of waste containers, if necessary.

Borehole or augured hole. The experience with using boreholes or augered holes for LLRW disposal is limited, due to the short period of time in which this methodology has been tested. In addition, some of this experience is with boreholes used for "storage" rather than "disposal," and built into the borehole design is a method for retrieving the waste.

In order to meet the requirements of Chapter 111H, the borehole would have to be lined with steel, fiberglass, concrete or some other strong, impervious material in order to provide an engineered barrier to isolate the waste in addition to the natural characteristics of the site.

In addition, Massachusetts law requires retrievability of waste in a disposal facility, if necessary. Much of the literature on the borehole concept assumes a migration of radionuclides due to failures in the shaft linings, seals, caps, and covers. If radionuclides have moved out of the borehole into adjacent soils, it may be difficult for them to be retrieved without digging out the entire area around and below the borehole.

A borehole constructed below the water table would require sophisticated engineering design to prevent the occurrence of the so-called "bathtub" effect, when surface or ground water fills up the hole, saturating the waste inside. It would also require a reliable system to monitor and mitigate any release of radioactive contaminants.

Above-Ground Disposal Facility Technologies

Above-ground technologies have appeal for use in Massachusetts because of the State's hydrogeology. The shallow depth of the water table in the Commonwealth increases the chances that water could serve as a pathway for exposure if waste were placed below-ground. An above-ground system may, therefore, provide greater protection of the waste from the public and the environment.

Above-ground technologies with earthen or engineered cover. Additional barriers to prevent the possibility of radiation exposure to the public and the "inadvertent" intruder enhance the basic design of uncovered above-ground facilities, as was noted in the Rogers and Associates report on "enhanced" above-grade earth-mounded concrete vaults. In the case of the above-ground vaults with earthen cover and the above-ground modular canisters with earthen cover, a thick layer of soil and other natural and man-made materials can be designed and installed over an above-ground structure to provide further protection. In

the case of the above-ground vaults with modular canister technology, a second engineered barrier provides even greater protection, and allows easier access to waste packages if retrieval becomes necessary.

Literature on various LLRW disposal technologies, including the Conceptual Design Report and the various volumes of the Alternative Methods for Disposal reports cited in this chapter, raise a question about uncovered above-ground technologies: the ability of concrete structures to ensure long-term stability of the waste, a necessary requirement of the NRC regulations. Indeed, research on the longevity and degradation of concrete is ongoing, both in the United States and abroad.

Concern over concrete use applies not only to uncovered (or unmounded) above-ground technologies, but to others as well that use concrete in one system or another (e.g., below-ground vaults).

The use of concrete-type materials in construction dates back to 2000 B.C. Pieces of the early Roman Empire projects, including the aqueducts built to carry water from the mountains, can be seen and are still in use today.[32]

Modern-day cement, known as Portland cement, was patented in 1824. Since that time, most of the research on modern concrete involved reducing the effects that degrade concrete in road and bridge construction; the question of concrete's long-term performance over hundreds of years in an LLRW disposal facility has been considered only recently.[33]

The NRC is currently sponsoring research to develop a model for predicting concrete's long-term performance for LLRW disposal. States, including Texas and Illinois have funded research on concrete because of their interest in building engineered disposal facilities. Concrete research is also being conducted by the U.S. Army Corps of Engineers, the American Society of Testing and Materials, the National Institute of Standards and Technology, the American Concrete Institute, and other industry associations.

Concrete research literature identifies five principal factors that affect concrete longevity. They are described very briefly below:

(1) Sulfate Attack. Sulfate salts such as sodium sulfate, calcium sulfate, and magnesium sulfate occur naturally in soil. The sulfates can cause concrete surfaces to erode and can also cause loss of structural strength. The impact of sulfate attack depends upon the concentration of sulfates, the quality of the concrete, the type of concrete, and the chemical harmony between the concrete and its sulfate environment.[34]

(2) Chloride Attack. Chloride salts such as calcium chloride, sodium chloride, aluminum chloride, and magnesium chloride are also found naturally in soil. They can corrode the steel in steel-reinforced concrete, leading to structural damage. Very small amounts (less than 2%) in concrete can also reduce the rate of sulfate attack.

(3) Leaching. Leaching is caused when water passes over concrete, and washes out water-soluble compounds such as alkali salts, calcium oxide, and calcium hydroxide. Leaching affects the concrete's structural integrity at a rate that depends upon the flow rate of water

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[32] Chang, W. and Hasan, N. (Ebasco Services, Inc.) Concrete Longevity Overview. DOE/LLW-105, EG&G Idaho and U.S. Department of Energy, Idaho Falls, ID, September, 1990.

[33] Ibid.

[34] Ibid.

surrounding the concrete structure.

(4) Alkali-Aggregate Reaction. Alkalis are water soluble salts produced during the cement mixing process. Aggregates are sand, stone, and gravel used to make concrete. These substances react to one another in cement paste,[35] and cause tiny internal cracks around the aggregate particles. The cracks themselves generally do not cause structural problems, but they can increase the permeability of concrete to water infiltration and lead to structural failure from other sources. This condition can be controlled by modifying the ingredients used in the cement mixture and by using high-quality aggregates.[36]

(5) Freeze-Thaw Damage. Freeze-thaw or frost damage occurs when concrete is exposed to fluctuating temperatures above and below the freezing point. Approximately 100 freeze-thaw cycles occur in the Northeast each year. The freeze-thaw action can lead to cracking and other cement damage. Reducing the ratio of water to cement in the concrete and using smaller size aggregate materials can reduce the damage caused by this condition.

Other factors that can lead to concrete degradation include erosion, abrasion, and acid rain.

The research involving concrete has been extensive, and the resulting literature indicates that the factors that degrade concrete can all be prevented or mitigated by the proper choice of materials, designs or operation so that concrete can provide long-term structural stability and serve as a waste isolation barrier for at least 500 years at an LLRW disposal facility.[37]

13.7 Cost-Effectiveness of LLRW Disposal Technologies and Practices

Determining which disposal "technologies" are cost-effective requires an analysis of the various LLRW disposal methods previously described in this chapter, as well as other disposal methods, such as combinations of some of the technologies described here. Determining which disposal "practices" are cost-effective requires a similar analysis of the costs of siting, building, and operating the cost-effective technologies within the state versus the costs of arranging for LLRW disposal out of state.

Figure 13-L lists factors that would have to be analyzed for each disposal technology in order to identify all the "cost-effective" disposal methods. The list in this table is not meant to be all-inclusive, but is representative of the major factors that must be evaluated to determine cost-effective technology.

After cost-effective disposal technologies are identified, the next step in this analysis is to determine whether constructing any of these technologies in-state is cost-effective as compared to the available alternatives: arranging disposal out of state or siting a centralized storage facility. NRC policy currently allows storage for no longer than five years. It is uncertain, therefore, whether the NRC would license a centralized storage facility to store waste for a longer period of time. Certainly, storage would not be approved as "de facto" disposal -- a policy opposed by the NRC. Remaining is the issue of the need to provide for ultimate disposal after centralized storage, and the disposal costs should therefore be factored into this equation.

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[35] Cement paste is a mixture of cement and water which may be hardened or unhardened.

[36] Op cit., Chang.

[37] Ibid.

For the purpose of selecting cost-effective disposal technologies from among these three alternatives, the costs developed through the process described in section 12.6 of Chapter 12 should be used as the costs for the disposal facility.

The analysis of the disposal location alternatives (i.e., in-state versus out-of-state disposal) depends substantially upon decisions concerning financing options. For example, at first blush, the cost-effectiveness to the Commonwealth if all disposal facility costs were financed by LLRW generators would seem to be intuitively obvious; under that scenario, the State would pay nothing and the generators would pay everything, thereby making that option the most cost-effective for the State, in terms of dollars expended.

Figure 13-L
Factors Relative to Cost-Effectiveness of LLRW Disposal Technologies

Site Selection	Construction Costs
Licensing	Operating Costs
Environmental Review	Closure Costs
Technology Design	Institutional Control Costs
Operating Procedures	Land Acquisition
Waste Characteristics	Waste Segregation
Treatment before Disposal	Amortization
Manpower	Interest Costs
Personnel Monitoring	Liability
Environmental Monitoring	Emergency Response
Packaging	Repackaging
Special Handling	Training
Equipment	Volume of Waste requiring Disposal
Health Risks:	Number of Engineered Barriers
Doses to Public	
Doses to Workers	
Doses to "Intruders"	

However, the Commonwealth should not ignore the financial impact that disposal decisions will have on the businesses, hospitals, universities, and other "users" of radioactive materials that produce LLRW. To do so could seriously affect the State's economy if some or all of the approximately 450 radioactive materials licensees were to move their radioactive materials-related activities to states that provide less expensive LLRW disposal.

These businesses provide hundreds of millions of dollars of benefit to the Massachusetts economy. A 1991 survey, described in Chapter 4 of this volume, identified over $3.03 billion dollars of benefit to the Massachusetts economy, and over 36,000 jobs directly and indirectly related to radioactive materials use. Their loss could have a significant effect upon the State's efforts to shore up the economy currently suffering from the national recession. The impact would be more than just economic. Hospitals might have to curtail medical procedures that produce LLRW, for example.

Before dismissing this alternative out of hand, however, a cost should be attached to this approach. Such a valuation would include lost tax revenue from the companies, lost income tax from the employees, increased unemployment benefits paid to the employees, and an estimate of the "multiplier effect" of the lost disposable income of the employees. With this information in hand, the cost-effectiveness of choosing to pass all costs onto the generators can be quantified and used for comparative purposes.

In evaluating in-state versus out-of-state disposal costs, four distinct disposal options should be considered:

(1) development of an in-state facility for Massachusetts only;

(2) development of an in-state facility available to a multi-state compact;

(3) use of a disposal facility in another state as a member of a multi-state compact; and

(4) entering into a contract arrangement with another state or region.

Each disposal arrangement involves a variety of cost factors that would be incurred directly or indirectly by the LLRW generators and the Commonwealth. These factors are listed in Table 13-6.

Table 13-6
Factors Relative to Cost-Effectiveness of Disposal Options

Factors Affecting Cost of Disposal Options	Disposal Option			
	Out-of-State[a]		In-State	
	Compact	Contract	Compact	Alone
Site Selection			X	X
Site Characterization			X	X
Disposal Method Design			X	X
Source Term Development[b]			X	X
Analysis, Documentation, and Licensing			X	X
Project Management & Quality Assurance			X	X
Public Participation			X	X
Legal/ Litigation			X	X
Land Acquisition			X	X
Construction			X	X
Community Impact Payments	X	X	X	X
Operations/ Disposal Fees	X	X	X	X
State/ Local Fees	X	X	X	X
License Maintenance/Amendments	X	X	X	X
State Monitoring Programs	X	X	X	X
State Health Studies			X	X
Closure			X	X
Post Closure Care			X	X
Waste Acceptance Criteria	X	X	X	X
Institutional Control	X	X	X	X
One-time Entry Fee	X	X		
Surcharges	X	X		
Out-of-State Transport Costs & Permit Fees	X	X		

[a] Most of these out-of-state costs would be indirectly incurred by Massachusetts generators or the Commonwealth through user fees, surcharges, or access fees assessed by the host state. Only those costs that would be directly assessed are checked in these columns.

[b] "Source term" is the process of identifying and inventorying the characteristics in the total waste stream, and projecting the total quantities of radioactivity over the facility's operating life, and beyond.

Costs for In-State Facilities

Total life cycle costs and user fees have been estimated for several types of in-state disposal facilities for Massachusetts. These examples do not represent an exhaustive list of possible disposal methods that might be considered for the Commonwealth, but three types of facilities have been chosen to illustrate approximate costs that may be expected for engineered disposal facilities. Also, it is possible that combinations of technologies might be used at one site for various disposal classes, or to provide multiple barriers.

Although more detailed and accurate economic analyses would be required for a specific site and technology, reasonable approximations can be made using accepted economic methods and generally accepted studies. Tables 13-7, 13-8, 13-9, and 13-10 summarize estimates based on the cost factors[38] and economic model[39] developed for DOE's National Low-Level Waste Management Program by EG&G, Idaho. This economic model has been used and accepted throughout the industry, and can provide reasonable life cycle cost estimates and user fees.

Table 13-7
Approximate Costs for In-State Massachusetts-Only LLRW Disposal Facilities
(35,000 Cubic Feet per Year Capacity)

	Disposal Costs for a 35,000 ft^3/yr Facility						
	Cost in $000						
Disposal Technology	Pre-operation	Initial Construction	Operation	Closure	Post-Closure	Total Life Cycle	User Fee, $ per ft^3
Above Ground Vaults, without covers	39,517	7,984	222,175	4,682	53,600	383,400	365
Below Ground Vaults	39,998	8,452	192,299	5,454	33,600	349,560	333
Modular Concrete Canisters (below ground)	39,883	11,464	186,386	6,202	43,300	351,690	335

Note: The numbers appearing in the "pre-operation" through "post-closure" columns represent actual funds required, whereas the last two columns account for the time value of money and interest payments.

Source: U.S. Department of Energy. "Disposal Site Economic Model." Idaho Falls, ID, 1988. Some factors used in the model come from Hill, P.J. and Smith, P.R., Facility Life Cycle Cost and User Fee Projections for Small Volume Low-Level Radioactive Waste Disposal Facilities. U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, February, 1989.

Similarly, the cost factors employed by the model are typical values and have been used in the absence of detailed, project-specific cost data. However, cost factors used in the EG&G model have been modified to include a recent Management Board estimate of pre-operating costs for siting a Massachusetts disposal facility. These updated pre-operating costs are significantly higher than the default values normally

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[38] Hill, P. J. and Smith, P. R., Facility Life Cycle Cost and User Fee Projections for Small Volume Low-Level Radioactive Waste Disposal Facilities. U.S. Department of Energy, National Low-Level Waste Management Program, EG&G Idaho, Inc., February, 1989.

[39] U.S. Department of Energy. "Disposal Site Economic Model User's Guide for Personal Computers." EG&G Idaho, Inc., March, 1988.

employed by the model, and reflect actual experience in developing new facilities in other states and estimates of Massachusetts-specific conditions. Other costs used in the earlier EG&G studies were based on 1986 dollars, and have been adjusted for inflation to represent 1992 dollars.

The tables also include estimated user fees based on life cycle cost estimates. The user fee is the average charge for use of the facility required to cover all of the costs listed, not including any surcharges that might be applied.

Approximate costs are summarized in Table 13-7 for 35,000 cubic feet per year facilities, in Table 13-8 for 50,000 cubic feet per year facilities, in Table 13-9 for 80,000 cubic feet per year facilities, and in Table 13-10 for 467,000 cubic feet per year facilities.

The 35,000 cubic feet per year facility capacity represents the average yearly volume expected for a Massachusetts-only facility, assuming that generators continue to reduce waste volumes through source reduction/elimination and LLRW minimization, as they have estimated in the Management Board's 1992 survey of current and future LLRW generation. The 35,000 cubic feet per year facility volume also assumes the receipt of decommissioning waste from only two sites, namely the two nuclear powered electric generating plants in the Commonwealth.

Table 13-8
Approximate Costs for In-State Massachusetts-Only LLRW Disposal Facilities
(50,000 Cubic Feet per Year Capacity)

Disposal Technology	Disposal Costs for a 50,000 ft^3/yr Facility						
	Cost in $000						User Fee, $ per ft^3
	Pre-operation	Initial Construction	Operation	Closure	Post-Closure	Total Life Cycle	
Above Ground Vaults, without covers	40,049	8,638	222,565	4,786	53,600	387,030	258
Below Ground Vaults	39,836	9,720	192,331	5,764	33,600	352,380	235
Modular Concrete Canisters (below ground)	40,269	12,906	182,996	6,797	43,300	353,460	236

Note: The numbers appearing in the "pre-operation" through "post-closure" columns represent actual funds required, whereas the last two columns account for the time value of money and interest payments.

Source: U.S. Department of Energy. "Disposal Site Economic Model." Idaho Falls, ID, 1988. Some factors used in the model come from Hill, P.J. and Smith, P.R., Facility Life Cycle Cost and User Fee Projections for Small Volume Low-Level Radioactive Waste Disposal Facilities. U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, February, 1989.

The 50,000 cubic feet per year capacity includes the average yearly volume expected for a Massachusetts-only facility, based on more moderate use of source reduction and LLRW volume minimization techniques, and decommissioning waste from several facilities, including both nuclear power plants. The 80,000 cubic feet per year capacity represents what might be expected for a small regional facility located in Massachusetts that accepted waste for disposal from a few other states, in addition to Massachusetts. The results illustrate the potential economies of scale associated with operation of a larger site. The user fees are significantly less for the 80,000 cubic feet "regional" facility compared to the 35,000 and 50,000 cubic feet "Massachusetts-only" facilities.

Table 13-9
Approximate Costs for Small Regional In-State Massachusetts LLRW Disposal Facilities (80,000 Cubic Feet per Year Capacity)

Disposal Technology	Disposal Costs for 80,000 ft^3/yr Facility						
	Cost in $000						User Fee, \$ per ft^3
	Pre-operation	Initial Construction	Operation	Closure	Post-Closure	Total Life Cycle	
Above Ground Vaults, without covers	40,527	9,292	248,001	5,591	59,600	416,730	174
Below Ground Vaults	40,172	10,581	209,321	5,999	36,600	373,080	155
Modular Concrete Canisters (below ground)	40,640	14,046	199,006	7,397	47,000	374,280	156

Note: The numbers appearing in the "pre-operation" through "post-closure" columns represent actual funds required, whereas the last two columns account for the time value of money and interest payments.

Source: U.S. Department of Energy. "Disposal Site Economic Model." Idaho Falls, ID, 1988. Some factors used in the model come from Hill, P.J. and Smith, P.R., Facility Life Cycle Cost and User Fee Projections for Small Volume Low-Level Radioactive Waste Disposal Facilities. U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, February, 1989.

Even greater economies of scale are evident with the 467,000 cubic feet per year facility size. That capacity represents a facility that could accommodate LLRW from most of the Northeast. The regional facility site sizes also include decommissioning LLRW expected from several large facilities.

Table 13-10
Approximate Costs for Large Regional In-State Massachusetts LLRW Disposal Facilities (467,000 Cubic Feet per Year Capacity)

Disposal Technology	Disposal Costs for 467,000 ft^3/yr Facility						
	Cost in $000						User Fee, \$ per ft^3
	Pre-operation	Initial Construction	Operation	Closure	Post-Closure	Total Life Cycle	
Above Ground Vaults, without covers	44,685	21,044	560,524	12,666	135,000	789,480	56
Below Ground Vaults	44,343	21,304	421,597	12,633	73,700	633,780	45
Modular Concrete Canisters (below ground)	45,286	28,279	401,475	14,894	95,300	637,290	46

Note: The numbers appearing in the "pre-operation" through "post-closure" columns represent actual funds required, whereas the last two columns account for the time value of money and interest payments.

Source: U.S. Department of Energy. "Disposal Site Economic Model." Idaho Falls, ID, 1988. Some factors used in the model come from Hill, P.J. and Smith, P.R., Facility Life Cycle Cost and User Fee Projections for Small Volume Low-Level Radioactive Waste Disposal Facilities. U.S. Department of Energy, National Low-Level Waste Management Program, Idaho Falls, ID, February, 1989.

Costs to Utilize Out-of-State Facilities

As illustrated in Table 13-6, many of the costs associated with development, operation, closure, and post-closure of out-of-state disposal options do not appear to apply directly to Massachusetts LLRW? generators. It is clear that the licensee community would be required to pay whatever disposal fees were applicable to any user of the disposal facility, but it is not evident what other charges might apply to Massachusetts generators. Surcharges could be levied to raise additional revenues for the host state, lessen the costs to host state or compact generators, or reduce the debt incurred in siting and developing the facility. For example, South Carolina law currently authorizes an additional charge of $160 per cubic foot on waste imported from outside the Southeast Compact region after Jan. 1, 1993. The $160 South Carolina fee is only a portion of the total $220 per cubic foot fee set by the Southeast Compact Commission to cover other expenses, including disposal facility development in North Carolina (the next Southeast Compact states' site) which generators -- including Massachusetts -- outside the Southeast Compact region have to pay in order to have 18 months of continued access to the Barnwell disposal site after 1992.

Another mechanism for regions or states to recover site development costs is to require a one-time "entry fee" in addition to the typical user fees. The entry fee may be a negotiated fee between the host state or compact and the state desiring to obtain access for its generators.

Texas is using the entry fee concept (plus other costs) as part of its new regional compact with Maine and Vermont, approved by the Texas Legislature in May, 1993. Maine and Vermont will each pay $27.5 million dollars in entry fees to use the Texas facility, by assessing the LLRW generators in those two northeastern states.

The level of entry fees that could be levied can vary widely, depending upon the "seller" state or compact's desire to make a profit over and above the costs of site development, and the "buyer" state's ability to finance the fee. For example, in recent discussions with Texas about the possibility of that state accepting Connecticut LLRW waste at the new Texas site, Connecticut officials offered to pay Texas a $100 million dollar entry fee. While Texas officials turned down that offer in favor of the $55 million it will instead receive from Maine and Vermont, the mere fact that the $100 million dollar offer was put "on the table" for consideration has the potential of influencing any other future entry fees that may be negotiated.

Legislation to finance the costs of in-state disposal facility siting or an "entry" fee payment to another state that might accept Massachusetts LLRW was adopted during the 1993 session of the Massachusetts Legislature. Chapter 428 of the Acts of 1993 authorizes $45 million dollars in general obligation bonds to be issued by the Commonwealth, and later repaid by LLRW generators, either when an in-state facility or an out-of-state agreement are reached, or in the year 2000, if no such disposal solutions are available by that time.

As noted, the life cycle cost estimates shown in Tables 13-7 through 13-10 are approximations of what these four facility sizes might cost, assuming the factors used in the cost-estimating model were designed and built into the actual facilities. While these estimates cannot be used to identify explicit expenditures for such facility sizes in Massachusetts, they are useful in evaluating the relative economies of scale for different facility capacities, assessing the range of user fees, and comparing each phase of disposal facility life cycle costs with similar phases in other states.

For example, Tables 13-7 through 13-10 estimate pre-operational costs ranging from $39.5 to $45.2 million dollars. These costs are comparable with estimates produced by studies in other states. One study cites the following pre-operational costs for some current projects:

Southwest Compact	$29,406,000

Central Interstate Compact	$31,760,000
Southeast Compact	$45,786,000
Appalachian Compact	$29,000,000[40]

A study completed for Texas[41] indicates that development costs for a below-ground, modular concrete canister, LLRW facility in that state were estimated to be $41 million. The facility was assumed to have a two million cubic foot capacity (about 67,000 cubic feet per year), and operate for 30 years. The study also estimated total life cycle costs to be $249 million with a user fee of about $195 per cubic foot for the first 20 years of operation.

It is possible that contract conditions for out-of-state LLRW might require a fee to cover costs such as these. A "substantial contribution" to offset development costs in any of these regions could mean an up-front payment ranging from $15 million to $100 million (50% to 100%). In addition, user fees for out-of-region waste could be substantial, as suggested by recent experience.

In addition to costs related to utilization of out-of-state disposal facilities, Massachusetts generators would also incur greater costs for transportation of LLRW to these more distant sites. Transportation rates are based on distance, weight, and other factors, but generally will vary in direct proportion to distance. Surcharges and permit fees to transport LLRW through other states may also apply to Massachusetts shipments out of state.

In summary, out-of-state disposal options could result in costs to the Commonwealth and the generator community consisting of:

(1) usual disposal site user fees and surcharges;

(2) additional disposal surcharges for out-of-state users;

(3) one-time disposal access entry fees; and

(4) additional transportation costs.

In-State/Out-of-State Comparison

The costs to develop a disposal facility in Massachusetts are not unlike those costs expected or experienced to develop facilities elsewhere. However, the assumed capacity of a facility does affect the user fee significantly. As shown by the four facility sizes illustrated above, economies of scale are evident. In any case, it is likely that the development of a disposal facility in Massachusetts will result in higher disposal fees for Massachusetts generators than they have incurred in the past due to:

- the greater costs of siting a facility today;

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[40] Hanrahan, Thomas P. "Economic Aspects of LLRW Disposal Compact Progress." Proceedings of the Symposium on Waste Management. Tucson, AZ: University of Arizona, February, 1991.

[41] Baird, R. et al. "Texas Low-Level Radioactive Waste Disposal Facility Design Using Modular Canisters For All Waste." Proceedings of the Symposium on Waste Management. Tucson, AZ: University of Arizona, February, 1991.

- the more highly engineered technologies required; and

- the smaller scale of a facility for Massachusetts.

Yet it is evident from these estimates and recent experience that out-of-state disposal options also may involve similar costs to both the Commonwealth and the Massachusetts generator community. From the preliminary economic data currently available, it appears possible that these costs could actually exceed the costs to provide an in-state facility. At this time, it appears likely that any LLRW disposal option involves significant costs to both the State and LLRW generators.

Who Finances the Costs

The important decision for the State in evaluating cost-effectiveness of disposal technologies and practices, therefore, is to determine whether the cost-effective technologies should be financed by the State, or whether, and to what extent, those costs can be passed onto the generators, versus whether those costs would be less if out-of-state disposal were available.

An analysis of the economic forces will enable the Commonwealth to determine what sort of state subsidy, if any, might be necessary or desirable in addressing cost-effectiveness. The subsidies could be:

(1) "front-end investment subsidies" in which the State funds various costs of providing in-state disposal, or pays the "entry" fees to entitle Massachusetts generators access to an out-of-state site;

(2) "operating subsidies" in which the State funds a portion of the operating costs or finance charges, or

(3) a combination of (1) and (2).

During the 1980s, the Commonwealth approached the disposal issue with the thought that the most appropriate way to finance the pre-operational costs of a disposal facility, if one were to be sited in Massachusetts, would be to subsidize these costs through the use of state bond authorizations. In the 1990s, faced with greater costs and shrinking dollars, the State has adopted a different financing option. As noted, the Massachusetts Legislature approved a $45 million dollar bond, with the condition that LLRW generators repay the Commonwealth once an in-state facility begins operating, or an out-of-state solution is available. And, if such an arrangement is not successfully completed by the year 2000, then the new law requires generators to begin repaying principal and interest that year.

The costs of pre-operational requirements are one of the two major expenditures involved in facility siting. The other is the cost to construct disposal units.

Pre-operational costs include the expenses related to facility siting and licensing. They include:

- statewide screening to eliminate all environmentally unsuitable areas from further consideration;

- pre-characterization of numerous potential facility sites;

- detailed site characterization of a few candidate sites;

- community review and public participation;

- selection of the final site;

- disposal technology selection and development;
- evaluation of the characteristics of the LLRW to identify the total length of time the half-lives of radioactive contaminants in the LLRW will take to decay to background levels, and the concentrations of these materials (i.e., the "source term");
- site purchase;
- licensing of the proposed facility;
- contract management;
- contractor expenses;
- environmental studies;
- quality assurance programs;
- legal expenses; and
- community compensation and impact payments.

The reason for the policy of state subsidies for pre-operational costs is apparent when a comparison is made of LLRW generators in Massachusetts versus other states. In other states and compact regions that are developing disposal facilities, the vast majority of waste (measured by both volume and radioactivity) is produced by nuclear-powered utility companies. Many of these states and compact regions assess only their power companies for the costs of developing LLRW disposal facilities, because the utility companies have the ability to offset these charges by passing them onto their rate-payers.

Table 13-11 summarizes the methods of financing pre-operational costs in several states that are or have been involved in disposal facility development.

In contrast, the majority of LLRW in Massachusetts has not been produced by the state's two nuclear-powered utilities. Rather, most of the waste is generated by other commercial, health care, academic and government licensees. Many of these businesses could find it financially difficult to pay the high assessments which would be necessary to cover all pre-operational activities.

Table 13-12 provides a breakdown of the average percentage of LLRW shipped for disposal from selected states, including Massachusetts, during the years 1990 through 1992 by the five different LLRW-generating categories: academic, government, commercial, health care, and utility. In states where most of the waste is generated by utility companies, the policy of assessing just the utilities (or most of the costs on the utilities) for the pre-operational expenditures of facility development may be justifiable, if this single generator group produces the vast majority of LLRW. The utility companies themselves are not materially impacted by this policy, as they pass the costs through to their rate-payers. Were Massachusetts to adopt this approach and assess the two nuclear-powered utility companies, state law allows them to bill their rate-payers for these fees.

An analysis of cost-effectiveness of in-state versus out-of-state disposal technologies and practices may be irrelevant if there are no options for out-of-state disposal. At the present time, all the states and compact regions that are developing LLRW disposal facilities have publicly indicated their unwillingness to accept Massachusetts waste either as part of a compact or through a contract. The Commonwealth is charged under state law with the responsibility of negotiating an out-of-state disposal solution, while at the

same time preparing to site, if necessary, an in-state disposal facility. The policies of the siting states and compact regions are critical to the Commonwealth's ability to pursue this dual approach.

Table 13-11
LLRW Disposal Facility Pre-Operational Financing Mechanisms

State or Compact region	Assessment on nuclear power plants	Charge per reactor	Credit against disposal fee?	Assessment on all generators?	Amount of general assessment	Frequency of fee(s)
New York	Yes	$3,000,000	Yes	No	–	Annual
Central Midwest Compact[a]	Yes	$1,098,000	Yes	Yes	$50 per year or $3 per cubic foot	Annual
Midwest Compact[b]	Yes	Between $227,500 and $1,235,000	No	No	–	Annual
Maine	Yes	$2,000,000	No	Yes	$79 up to $391,834	Annual
Appalachian Compact[c]	Yes	$933,000[d]	Yes	Voluntary	–	Annual
Central Compact[e]	Yes	[f]	Yes	Yes	$500-$65,000/yr	Annual
Texas[g]	No	–	–	No	–	–
Southwest Compact[h]	No	–	–	No	–	–
Massachusetts[i]	No			No[i]	–	–

[a] The Central Midwest Compact includes Illinois (host state) and Kentucky.
[b] The Midwest Compact includes Indiana, Iowa, Minnesota, Missouri, Ohio (host state) and Wisconsin.
[c] The Appalachian Compact includes Delaware, Maryland, Pennsylvania (host state) and West Virginia.
[d] This figure represents the Fiscal Year 1992 nuclear power plant assessment. In Fiscal Year 1991, the charge had been $1,200,000.
[e] The Central Compact includes Arkansas, Kansas, Louisiana, Nebraska (host state) and Oklahoma.
[f] Under a contract with the Central Compact Commission, the nuclear utilities will pay a total of $47,000,000 for facility development. Assessments are made quarterly based on prorated volumes shipped by each reactor and expenses incurred.
[g] Texas has funded all development costs to date through annual legislative appropriation, but will recover all state expenditures from "entry" fees totalling $55,000,000 to be paid by Maine and Vermont as part of the new Texas compact requirements.
[h] The Southwest Compact includes Arizona, California (host state), North Dakota and South Dakota. California's site developer/operator, U.S. Ecology, is funding all pre-operational costs, but expects to recover through user fees when the facility opens.
[i] Massachusetts has an annual assessment law, but it does not fund pre-operational costs, since the Management Board has not voted to initiate siting. The assessment raises a maximum of $500,000 each year to help pay the Board's administrative (not siting-related) costs.

Source: Low-Level Radioactive Waste Management Board, September, 1992.

Finally, it should be noted that the most cost-effective disposal technology ultimately may not be the one selected, as the site community is charged under Massachusetts law with fulfilling that responsibility. [Chapter 111H, section 27] The community will select the type of technology that it believes best protects

Table 13-12
Average of Percentages by Generator Categories of LLRW Shipped for Disposal in 1990, 1991, and 1992

State	Average Total Volume	Average Total Activity	Academic		Commercial		Government		Health		Utility	
			Average % Volume	Average % Activity	Average % Volume	Average % Activity	Average % Volume	Average % Activity	Average % Volume	Average % Activity	Average % Volume	Average % Activity
Alabama	16,965	33,489	1.3	0.0	3.2	0.0	0.7	23.2	0.1	0.0	94.7	76.7
Arizona	21,817	717	3.9	0.4	1.9	2.8	0.7	0.3	0.1	0.1	93.5	98.4
Arkansas	9,189	11,136	1.1	0.0	0.5	87.1	0.2	3.2	0.4	0.0	97.7	9.6
California	80,354	9,439	14.5	0.9	45.1	68.2	10.2	8.8	6.6	0.6	23.7	23.5
Connecticut	45,328	96,009	3.7	0.0	18.5	0.0	8.3	0.0	0.6	0.0	68.8	100.0
D.C.	1,114	13	14.2	3.8	4.0	69.5	33.0	15.4	48.8	8.8	0.0	2.5
Florida	22,420	2,981	2.5	0.0	2.2	0.1	0.1	1.0	0.2	0.0	94.9	98.8
Georgia	40,014	25,398	1.3	1.7	10.4	0.1	0.2	5.3	0.0	0.0	88.0	92.9
Illinois	161,778	40,413	0.7	0.0	39.7	0.3	0.5	0.4	0.8	0.0	58.3	99.3
Iowa	7,940	26,807	36.5	0.1	9.0	0.0	0.0	0.0	0.1	0.0	54.5	99.9
Kansas	5,035	914	5.1	0.2	25.6	63.6	17.7	11.3	0.0	0.1	51.6	24.9
Louisiana	15,345	2,166	1.0	0.0	4.6	0.1	0.0	1.4	0.1	0.0	94.3	98.5
Maine	8,701	2,893	0.3	0.0	1.2	0.0	27.9	0.9	0.0	0.0	70.5	99.1
Massachusetts	43,873	71,432	1.4	0.0	33.1	83.8	25.1	0.1	1.6	0.0	38.8	16.1

Table 13-12
Average of Percentages by Generator Categories of LLRW Shipped for Disposal in 1990, 1991, and 1992
(continued)

State	Average Total Volume	Average Total Activity	Academic		Commercial		Government		Health		Utility	
			Average % Volume	Average % Activity	Average % Volume	Average % Activity	Average % Volume	Average % Activity	Average % Volume	Average % Activity	Average % Volume	Average % Activity
Mississippi	9,524	2,247	0.6	0.1	4.8	0.1	0.2	0.4	0.2	0.0	94.3	99.4
Missouri	16,660	1,698	15.1	5.1	62.2	20.5	0.0	0.8	0.1	0.0	22.3	73.5
Nebraska	12,959	34,107	0.9	0.0	2.1	0.0	0.1	0.1	0.0	0.0	96.9	99.9
New Jersey	60,479	32,461	4.8	0.0	27.4	0.6	0.2	0.1	23.7	0.0	43.9	99.1
New York	80,289	68,812	2.8	0.1	20.4	[illegible]	0.1	0.[illegible]	[illegible]	0.0	66.8	95.4
Ohio	23,563	3,865	4.7	0.7	13.2	0.7	10.3	9.7	0.6	0.0	71.0	88.9
Pennsylvania	139,738	180,965	1.0	0.0	38.2	1.1	0.3	[illegible].8	1.3	0.0	59.2	95.3
Rhode Island	298	1	12.7	9.0	0.0	60.5	0.0	0.0	87.2	30.5	0.0	0.0
South Carolina	46,083	2,276	1.4	0.1	33.2	[illegible].6	20.2	[illegible].7	0.0	0.0	45.2	86.4
Washington	50,715	4,535	3.0	0.5	32.3	68.5	38.1	[illegible].8	0.1	0.0	25.8	29.1
Wisconsin	7,780	721	1.8	0.1	6.5	0.[illegible]	0.2	10.4	0.5	0.0	90.9	95.3

Note % <0.1 shown as 0

Source: U.S. Department of Energy, Low-Level Radioactive Waste Management Program. 1990,1991,and 1992 State-by-State Assessment of Low-Level Radioactive Waste Received at Commercial Disposal Sites. Idaho Falls, ID, September 1991, 1992, and 1993.

the health, safety, and other interests of its population. Cost, therefore, may not necessarily be the deciding factor.

13.8 Recommendations to Improve Safety or Efficiency

Regardless of the type of technology chosen by the site community, if Massachusetts needs to site an LLRW disposal facility within the state, there are a number of issues, that could improve the safety or efficiency of such a facility, which need to be addressed by the Commonwealth. These are summarized below.

Recommendations to Ensure Environmental Protection and Public Safety

Assistance to candidate site communities on evaluating disposal technologies. The Management Board will provide technical assistance to potential disposal facility site communities to aid them in evaluating LLRW disposal technologies and practices, and their suitability at each candidate site location.

Careful evaluation needed of waste acceptance conditions. The conditions for acceptance of waste to be disposed of in an LLRW disposal facility are required to be reviewed by the Management Board each year, upon the submission by the facility operator of criteria for waste acceptance. [Chapter 111H, section 38] The Management Board needs to evaluate carefully such factors as waste form, stability, and potential pre-treatment requirements to enhance the ability of the facility to dispose of waste safely, to keep radiation exposures as low as reasonably achievable, and to operate in a manner most protective of the public health, safety, and the environment.

Waste acceptance criteria regarding GTCC disposal. In considering waste form, stability, and other factors pertaining to waste acceptance criteria, the Board should evaluate the implications of approving waste acceptance criteria that could result in concentrating the amount of activity in the waste, and thereby moving some LLRW out of Class A, B, or C, and into the Greater than Class C (GTCC) waste category. While GTCC waste disposal is the responsibility of the federal government, it has not yet succeeded in siting a facility for this waste. The Management Board will monitor the federal government's process to establish such a GTCC facility, recognizing that its actions regarding waste acceptance criteria at a Massachusetts-based disposal facility could affect the GTCC waste issue.

Recommendations to Ensure Environmental Protection, Public Safety, and Occupational Safety

Monitor potential radionuclide movement below and adjacent to disposal unit. Appropriate monitoring systems should be installed to monitor both below and adjacent to each disposal unit, in order to detect any radionuclide movement immediately.

Facility design should consider rainwater entry into, and draining away from, disposal units. Methods should be employed during the operation of any disposal facility to ensure that water will drain away from the disposal units. In addition, waste packages should not be placed into disposal units during adverse weather conditions, unless methods are followed to prevent rainwater entry into the units.

Segregate long-lived and short-lived LLRW. Waste should be segregated at any disposal facility by short and long radioactive half-life, to enhance safety and efficiency in any retrieval activity that may later be required.

Carefully evaluate Class C packaging. Because disposal of Class C waste poses the greatest long-term potential radiological threat (depending upon the disposal technology selected by the site community) consideration should be given to requiring additional barriers, including packaging, for Class C waste disposal, besides those provided by the disposal facility technology.

Prepare mitigation plans before facility operation. Remedial action plans, containing basic policies for handling general categories of potential contamination incidents, should be prepared and submitted for approval prior to operation, in the unlikely event of a contamination incident.

Plan needed for disposal of monitoring samples. A plan for disposing of water, soil, and other materials collected during monitoring and sampling should be prepared and submitted for approval prior to operation.

Recommendation for Action to Ensure Economic Protection for the Commonwealth

Review user fees to assure long-term care, third-party liability, and decommissioning funds availability. Disposal fees should be evaluated carefully to ensure that the contingent liability and institutional control accounts within the Low-Level Radioactive Waste Trust Fund[42] will contain enough funds to:

(a) maintain the facility properly throughout the institutional control period,

(b) provide for compensation should there be injuries to persons, land, or property, and

(c) provide decommissioning funds in the case of premature facility closure.

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[42] The Low-Level Radioactive Waste Trust Fund is established by Chapter 111H, section 41, to ensure sufficient funds for all activities during the institutional control period after the disposal site closes, and to cover any liabilities to the Commonwealth.

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Chapter 14: Decommissioning Applies to More Than Nuclear Power Plants

14.1 Introduction

Decommissioning is frequently associated with the shut-down and dismantling of a nuclear-powered electric generating plant. However, decommissioning pertains to all types of activities involving the licensed possession and use of radioactive materials, once the utilization of those materials has ceased. Those activities include radioactive materials used in numerous applications, including use by hospitals, universities, biotechnology companies, radiopharmaceutical industries, municipal water departments, and other government-related operations, and nuclear power plants. Each type of use eventually involves some form of decommissioning, with varying levels of complexity.

This chapter describes various decommissioning methods, and summarizes federal decommissioning regulations. The chapter also discusses the implications of decommissioning on managing low-level radioactive waste (LLRW), and the LLRW management impacts of the current decommissioning activity at the Yankee Rowe nuclear-powered electric generating plant, the oldest (and second smallest) plant in the country, which is located in Rowe, Massachusetts. In addition, the chapter offers some recommendations about state policies on decommissioning.

14.2 Decommissioning Defined

The U.S. Nuclear Regulatory Commission (NRC) defines "decommissioning" in its regulations in Title 10, Part 30, of the Code of Federal Regulations [10 CFR 30], as the safe removal from service of an activity involving radioactive materials or waste, and the reduction of residual radioactivity to a level that permits the release of the property for unrestricted use, as well as the termination of the license.

Decommissioning is different from "decontamination," which means the removal of radioactive material from surfaces such as building walls and floors, tools and equipment, or from fluids. Decontamination is clean-up that occurs both during and after operation; decommissioning is clean-up that occurs after an activity involving radioactive materials ceases. Decontamination procedures may also be used as a part of decommissioning activities. Decontamination normally produces additional quantities of waste, but generates less than would have been produced without the decontamination process. For example, waste is produced when radioactive surface contamination is removed from walls or floors by stripping or removing protective coatings. Without such activity, more waste would likely be generated if the entire floor or wall had to be included as LLRW. Decommissioning also generally produces additional waste, unless the waste contains only short half-life material[1] which can be stored for decay, a procedure in which LLRW with a

[1] The "half-life" of a radioactive material is the time in which half the atoms of the radioactive substance disintegrate to another nuclear form.

relatively short half-life is held for natural radioactive decay, so that the resulting waste, when it becomes essentially non-radioactive, may be disposed of as conventional solid waste.

Decommissioning can involve the removal from a location of all types of radioactive materials and waste, including LLRW, mixed waste, spent nuclear fuel, high-level radioactive waste (HLRW), and transuranic waste.[2] The removal of other hazards from the same location, such as structural (building) hazards, electrical hazards, or chemical waste hazards, is not considered an "official" part of decommissioning activities. However, in particular, the hazardous waste status at a site would have to be resolved to the satisfaction of federal or state hazardous waste regulators, before the site could truly be considered safe for "unrestricted use."

Decommissioning requirements apply to all activities using radioactive materials licensed by NRC,[3] including academic, commercial, government and utility-related activities. In order to terminate their licenses, all licensees in Massachusetts must decommission their facilities and submit reports to the NRC, as licensing agency, verifying that radioactive contamination has been reduced to meet criteria for release for unrestricted use of the site, and that release of the facility and site for unrestricted use will not constitute an unreasonable risk to the public.

Different degrees of decommissioning activity occur at different types of licensees' sites, depending upon the quantity, type, and use of licensed radioactive materials. Decommissioning rules are summarized in section 14.5 of this chapter. In general, however, decommissioning at a company licensed only to use a sealed source containing radioactive material[4] would involve the removal of the sealed source from the licensee's site. For example, most medical licensees use predominantly short-lived radioactive materials, as well as sealed sources; therefore the impacts of decommissioning would be relatively small.

In the case of a medical, university or commercial licensee that uses radioactive materials for diagnosis and treatment of diseases, education, research, or the manufacture of products, decommissioning

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[2] "Mixed waste" is LLRW that contains materials listed as, or exhibits characteristics of, toxic chemical "hazardous" waste. "Spent nuclear fuel" or "spent fuel" is defined as fuel that has been withdrawn from a nuclear reactor following irradiation, has undergone at least one year's decay since being used as a source of energy in a power reactor, and has not been chemically separated into its constituent elements by reprocessing. [10 CFR 72.3]. Spent fuel is stored in a nuclear reactor facility's spent fuel "storage pool" due to the unavailability of spent fuel disposal facilities in the United States. "High-level radioactive waste" or "HLRW" is defined by the NRC as spent nuclear fuel or the radioactive wastes produced during the reprocessing of spent fuel. Transuranic waste (TRU) is radioactive waste containing more than 100 nanocuries per gram of alpha emitting radionuclides with half-lives greater than 20 years and atomic numbers greater than 92. The federal government is responsible for the disposal of spent fuel, HLRW, and TRU.

[3] Users of radioactive materials in Massachusetts and other states are licensed by the NRC unless the State has entered into an agreement with that federal agency to assume regulatory control over certain licensed activities. (The NRC never relinquishes regulatory control over nuclear power plants, federal installations, research reactors, or the storage of spent fuel or other types of HLRW.) A state that has received NRC authority to regulate radioactive materials users and LLRW storage, treatment, and disposal facilities is called an "Agreement State." Massachusetts has applied for Agreement State authority. Until such authority is approved, all radioactive materials licensees in the Commonwealth are regulated by the NRC.

[4] A "sealed source" is radioactive material that is encased in a capsule designed to prevent leakage or escape of the radioactive material.

would involve the removal of all radioactive materials and waste. Such activity may include the removal of any radioactivity from equipment, countertops, and floors through various methods of decontamination. Some laboratory and other types of equipment may also be shipped as LLRW.

If a university were decommissioning a research reactor, such as the ones located at the Worcester Polytechnic Institute in Worcester, the University of Massachusetts at Lowell, and the Massachusetts Institute of Technology in Cambridge, the operation of these reactors at extremely low thermal power (10 megawatts or less) results in levels of system and facility contamination or activation of materials significantly lower than commercial power reactors. As a result, decommissioning activities will produce substantially less LLRW volume and activity than would be expected from larger, more powerful reactors. However, a decommissioning waste stream is expected from these facilities in the future.[5]

In the case of a nuclear-powered utility plant such as the Yankee Rowe facility that shut down in October, 1991, and the Pilgrim Nuclear Power Station in Plymouth (whose decommissioning is not expected until the expiration of the electricity generating license expires in 2012), decommissioning also involves the removal of all radioactively-contaminated materials from the site, including LLRW, spent fuel,[6] and mixed waste.

Because the disposal of spent fuel is the federal government's responsibility, a "Monitored Retrieval Storage" (MRS) facility to <u>store</u> this waste <u>temporarily</u> is being sited by the U.S. Department of Energy (DOE), which is also working to establish a HLRW <u>disposal</u> facility at Yucca Mountain, Nevada. Figures 14-A and 14-B illustrate these proposed facilities. Estimates vary as to when these sites will open, but the MRS facility is generally thought <u>not</u> to become available until around the year 2,000; and the HLRW site, not until around 2016.

Decommissioning may not be able to be completed at the Rowe plant for perhaps a decade or more, as no disposal facilities exist for the spent fuel wastes present at the power plant site. Although most of the nuclear reactor components and other facilities can be "safely removed from service," and shipped to an LLRW disposal site, the entire property cannot be released "for unrestricted use" unless the spent fuel waste can be removed, and final inspections verify that required decontamination is complete. Although off-site spent fuel storage may become available in the future -- once the MRS facility is operational -- it is expected that spent fuel from the Yankee Rowe reactor will be stored on site for some period of time.

NRC regulations permit spent fuel wastes to remain on site for up to 30 years after a reactor ceases operation. This can be accomplished under two regulatory mechanisms:

(1) The utility's 10 CFR Part 50 license enables the company to store spent fuel in certain specially-designed dry storage casks. This type of storage allows the decommissioning of all areas associated with the plant's operation, including the reactor fuel pool. After the spent fuel is removed from the site, the decommissioning would be finally completed.

(2) The utility could apply for a 10 CFR 72 license for the independent storage of spent fuel. If approved, these wastes could be stored on site under the new license, allowing the "Part 50"

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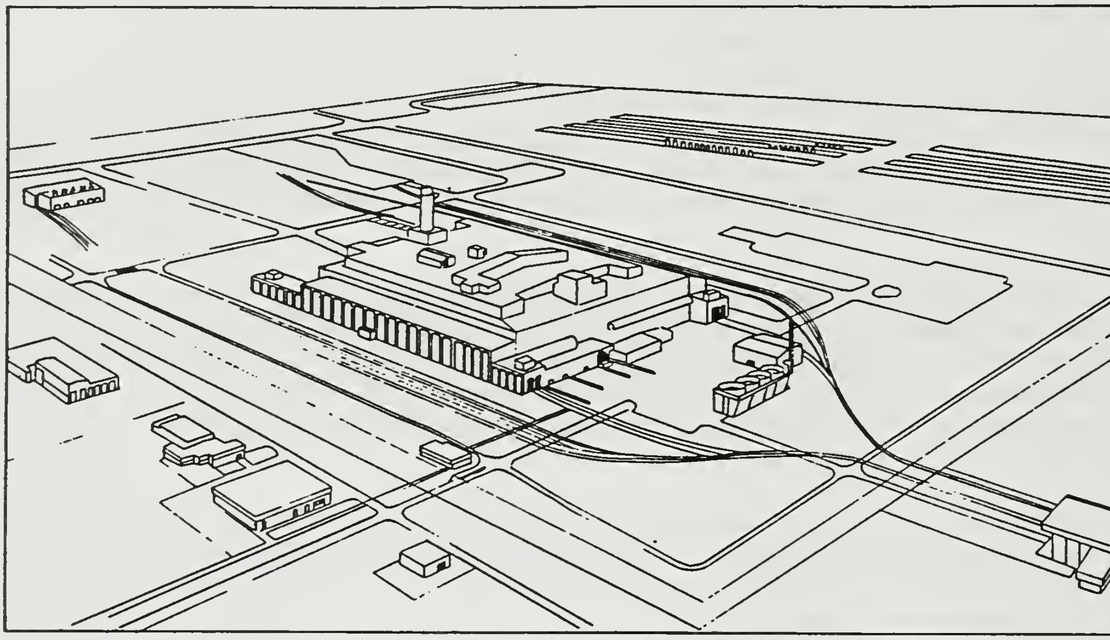
5 The site of an old research reactor in Watertown, operated by the U.S. Army until it was shut down in 1970, began the decommissioning process in 1992. The reactor core and other contaminated sources and components were removed years ago, but residual radioactive contamination remained within the reactor building and laboratories, and had to be removed.

6 "Spent fuel" and "HLRW" are defined separately in the 1982 federal Nuclear Waste Policy Act. However spent fuel is defined by the NRC for regulatory purposes as a category of HLRW.

license decommissioning to be completed and the "Part 50" license to be terminated. Under this regulatory scenario, the site would become free of all residual radioactive contamination from the perspective of the "Part 50" nuclear power plant operating license, but the presence of spent fuel stored under a "Part 72" license would not allow the property to be released "for unrestricted use."

Figure 14-A
Design for Spent Fuel Monitored Retrievable Storage Facility



Source: U.S. Department of Energy. Draft 1988 Mission Plan Amendment, DOE/RW-0187, June, 1988.

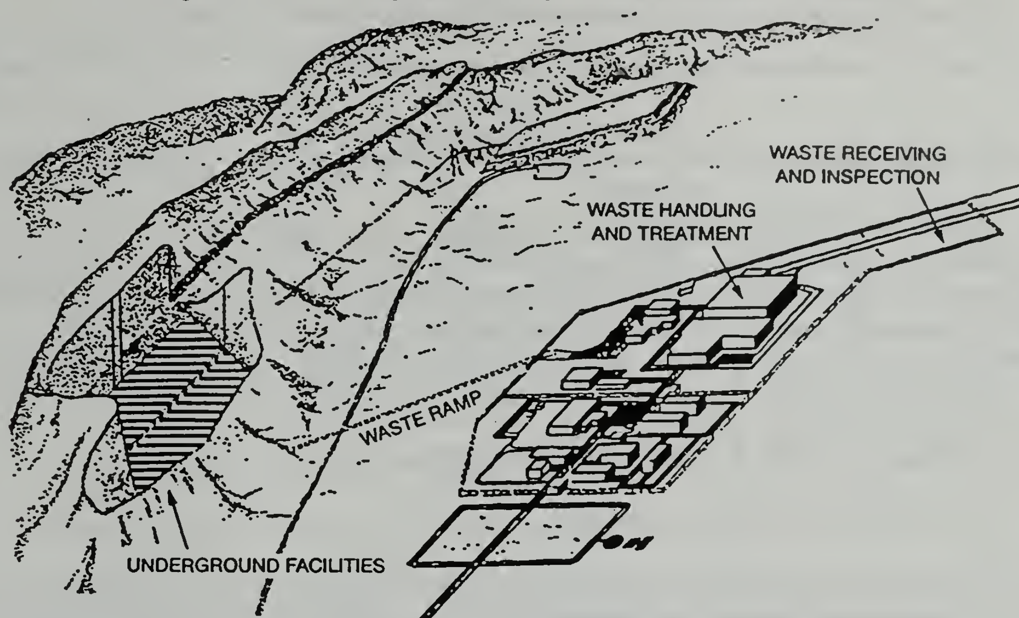
14.3 Old Burial Sites

In addition to the decommissioning of current licensed facilities, decommissioning pertains to the removal of radioactive waste buried years ago on various sites, when such burial was legally allowed under the federal regulations of the time. "Decommissioning" also is used to describe clean-up activities to remove radioactive materials or wastes that were legally or illegally disposed of in unlicensed LLRW disposal sites.

DOE is responsible for several environmental restoration programs involving decontamination and decommissioning at sites throughout the country. One such program, the Formerly Utilized Sites Remedial Action Program, or FUSRAP, includes two sites in Massachusetts: the Shpack Landfill in Norton, and the Ventron Corporation site in Beverly.

FUSRAP primarily addresses waste clean-up of sites that were formerly used to support nuclear research activities of no-longer-existing federal agencies, including the U.S. Atomic Energy Commission

Figure 14-B
Design for HLRW Disposal Facility, Yucca Mountain, Nevada



Source: U.S. Department of Energy. Draft 1988 Mission Plan Amendment, DOE/RW-0187, June, 1988.

(AEC) and the Manhattan Engineering District, which was set up to support the Manhattan Project.[7] The two Massachusetts sites involved in present clean-up activities were privately-owned and were used for research, processing, and storage of uranium and thorium ores. The contaminated waste material requiring clean-up is comprised mostly of soil and building rubble, and is classified as LLRW.

The sites in the FUSRAP program were decommissioned after their usefulness was exhausted, in some cases 30 or 40 years ago. However, because decommissioning health and safety guidelines were more relaxed and less stringent at that time, the AEC surveyed all the old sites in 1974 to characterize their radiological conditions. As a result of the AEC assessment and public pressure for site remediation, the DOE formalized the FUSRAP program in 1977.

The FUSRAP program has three principal goals for environmental remediation of the sites involved:

(1) to implement appropriate remedial actions or controls;

(2) to establish storage or disposal sites in consultation with the affected states; and

(3) to certify the acceptability of the sites for future use.

The total volume of LLRW from all FUSRAP sites nationwide is estimated to be 56 million cubic feet. The total waste from the two Massachusetts FUSRAP sites is estimated at 193,283 cubic feet. Because

[7] "Manhattan Project" was the federal government's code name for its research and development work, conducted during World War II, to collect uranium and plutonium necessary to harness the fission process and produce atomic bombs.

these cleanups are federal responsibility, all this LLRW will go into DOE LLRW disposal sites, not state disposal sites, unless the DOE can arrange for some or all of the waste to be accepted at state facilities.

The two FUSRAP locations in Massachusetts are summarized in Table 14-1.

Table 14-1
FUSRAP Sites in Massachusetts

Site	Location	Site Area (acres)	Estimated Waste Volume (cubic feet)	Waste Description	Principal Contaminants	Status	Permanently Stored LLRW (cubic feet)
Shpack Landfill	Norton	7,907	10,782	Soil, concrete, metal, rubble	U-238, U-235, Ra-226, Pb-210	Remedial action planned in Fiscal Year 1995	None
Ventron	Beverly	2,965	182,501	Soil, concrete, metal, rubble	U-238	Partially finished; completion scheduled for Fiscal 1993-94	6,213

Source: Oak Ridge National Laboratory, U.S. Department of Energy. Integrated Data Base for 1991: U.S. Spent Fuel and Radioactive Waste Inventories, Projections and Characteristics. DOE/RW-0006, Rev. 7, Washington, DC, October, 1991.

As noted in Chapter 13, prior to the adoption of the NRC's disposal regulations in 1983, licensed users of radioactive materials were legally allowed to bury certain types and quantities of LLRW on site. A handful of Massachusetts materials users followed this procedure until they were discouraged from burying wastes on their company lands.

The Low-Level Radioactive Waste Management Board wants to identify every old burial site in Massachusetts, and has been collecting information from a variety of sources. The Board has contacted every municipal Board of Health, and all regional Massachusetts Department of Environmental Protection (DEP) offices, requesting any information about possible old burial sites. In addition, the Board has contacted the NRC, and is seeking information from the files of the NRC's predecessor agency, the AEC. Because all old AEC files were placed in storage after the agency ceased to exist, records have been difficult to locate of old burial activities that had been approved by that agency. The NRC has retained a consulting firm to sort through all the old AEC files.

The Management Board has already inventoried several old burial sites from information supplied by NRC, DOE, the Massachusetts Department of Public Health (DPH), and other sources. These sites are:

(1) Army Materials Technology Laboratory, Watertown

(2) Engelhard Company, Plainville

(3) General Services Administration, Watertown

(4) Interstate 190 access ramp, Worcester (site of LLRW burial by the Norton Company, Worcester)

(5) New England Primate Research Center, Southboro

(6) Nuclear Metals, Inc., Concord

(7) Shpack Landfill, Norton

(8) Texas Instruments, Attleboro

(9) Wyman-Gordon, Grafton

(10) Ventron Corporation, Beverly

Completing decommissioning so that a location can be released for unrestricted use eliminates potential problems that could result in the future from sites containing radioactive contamination. The concern over such potential future problems recently influenced the NRC to announce a list of 46 sites nationwide whose decommissioning activities that agency has decided should be accelerated. While the NRC believes none of these sites pose immediate public health, safety, or environmental threats, they are concerned about the potential long-term impacts. Therefore, NRC has directed their cleanup:

(1) to avoid the potential for groundwater contamination from radioactive material;

(2) to remove large quantities of contaminated equipment, soils or structures; and

(3) to clean up sites where issues involving the financial liability of site owners have slowed progress toward the completion of all decommissioning requirements.

Six sites on the NRC's accelerated decommissioning list (officially called the "Site Decommissioning Management Plan") are located in Massachusetts, and are among the old burial sites inventoried by the Management Board. Their status is summarized in Table 14-2.

Upon becoming an Agreement State, Massachusetts would assume responsibility for regulating the cleanup of these sites. Under the Agreement State program, NRC would relinquish all authority with respect to these licensees, the cleanup of their facilities, and the termination of facility licenses.

Table 14-2
MA Sites in NRC Accelerated Decommissioning Action

Site Name	Location	Potential Hazards	Status/Comments
Watertown Arsenal Army Materials Technology Laboratory, and Mall Area	Watertown	Inhalation, Ingestion, Groundwater contamination	Research reactor used by U.S. Army until shutdown in 1970. Reactor core removed in early 1970s. Remaining contaminated material from the reactor activity, and several research laboratories, has been in a 20-year period of safe storage (SAFSTOR) involving continuous care, security, surveillance and maintenance while much of the radioactivity decays. All radioactive material has been removed from the AMTL site, and shipped to an LLRW disposal site. The licensee is performing final radiation surveys. If these are accepted by NRC, NRC will have final confirmatory surveys performed in June, 1995, prior to terminating the license and releasing the site for unrestricted use in June, 1996. As for the "Mall Area" site, NRC expects to have an action plan developed by June, 1994.

Table 14-2
MA Sites in NRC Accelerated Decommissioning Action
(continued)

Site Name	Location	Potential Hazards	Status/Comments
General Services Administration, Watertown Arsenal	Watertown	Inhalation, Ingestion, Groundwater contamination	Research using radioactive materials began at the Arsenal complex in 1946. Research conducted by M.I.T., American Cyanamid, U.S. Army, etc. Much of the research involved use of depleted uranium. GSA site is a 12-acre site on north side of Arsenal Street, and northeast of AMTL site. The GSA area served as packaging and radioactive waste storage area for entire complex; uranium scrap was also burned there. Surveys conducted in 1981 revealed that the GSA buildings were free of contamination, but some soils at the site were contaminated with radioactivity. Site decontamination was Initiated by GSA in 1988. In 1989, the discovery of an underground oil storage tank limited future activities. The U.S. Army Corps of Engineers is conducting a new assessment of decommissioning needs, and NRC has requested additional characterization of a portion of the site. If clean up continues on schedule, the site will be released for unrestricted use in July, 1994.
Engelhard Corp.	Plainville	Groundwater contamination	The previous site owner, D.E. Makepeace Company, fabricated nuclear fuel elements under an AEC license in the 1950s and early 1960s. During this time, the licensee was allowed to discharge uranium-contaminated effluent to a septic system on site, and to incinerate uranium-contaminated solid waste on site. When the license was terminated, only indoor areas were surveyed for unrestricted release. The outdoor contamination was discovered during a hazardous waste site investigation. No assessment yet exists of the amount of radioactive contamination, since much of the outdoor contamination is under pavement. Because the site is also contaminated with heavy metals and organic solvents, mixed wastes are expected to be present, as well. Engelhard is currently negotiating with EPA on the details of the site characterization/ remediation effort. Engelhard submitted a decommissioning plan for the building contamination in April, 1993, to NRC. NRC has asked that the radioactive site characterization/remediation be combined with the same activity required for hazardous waste by EPA. Decommissioning Is anticipated to be completed by December, 1994. Following a confirmatory survey by NRC, the site may be released for unrestricted use by August, 1995.
Nuclear Metals, Inc.	Concord	Groundwater contamination	NMI manufactures products from depleted uranium. Between 1958 -1985, NMI discharged approximately 750,000 pounds of copper and depleted uranium into an unlined holding basin on its site. In 1986, the basin was covered with a synthetic cover. Groundwater sampling Is conducted routinely. Due to previously Identified volatile organic compound (VOC) contamination in the groundwater, MA DEP placed NMI on the State's hazardous waste cleanup list, and classified the site as a "priority site" for cleanup, requiring DEP approval of all mitigation measures. NMI is agreeable to the decontamination and decommissioning of the basin, and has proposed a method to recycle the reusable materials in the basin, rather than have them disposed of as LLRW. NRC has requested additional information on site hydrology with respect to the migration of uranium from the basin. Negotiations over the best course of action are on-going.

Table 14-2
MA Sites in NRC Accelerated Decommissioning Action
(continued)

Site Name	Location	Potential Hazards	Status/Comments
Texas Instruments	Attleboro	Inhalation, Ingestion, Intrusion, Groundwater contamination	Site previously owned by Metals and Controls, Inc., which fabricated enriched uranium foils beginning in 1952. Company later merged with Texas Instruments, which fabricated fuel for the U.S. Navy between 1957-1983. Some materials and equipment were buried on site which were contaminated with low levels of uranium and thorium. Groundwater monitoring in 1983 and again in 1993 indicated no radiation levels above background. TI submitted decommissioning plans to the NRC In 1978, 1981, and 1992, and some contamination was removed In 1983, 1992, and 1993. NRC has requested an acknowledgement from TI that radioactive material from its site was disposed of in the Shpack landfill, a nearby site containing radioactive and hazardous wastes. TI has not provided this acknowledgement. With regard to the hazardous wastes at the Shpack landfill, TI and several other companies entered into a consent order with EPA. EPA's "findings of fact," contained In its consent order, state that EPA has reason to believe that "TI arranged for disposal of hazardous substances, including uranium wastes, at the Shpack landfill." NRC states that based on this finding, and all other information available, it considers the material in the Shpack landfill "likely to be that removed from the Attleboro (TI) site, and plans to proceed from that consideration."[1] In 1992, the Low-Level Radioactive Waste Management Board recommended that TI remove the contamination from Its property, despite the disagreement over the issue of liability at the Shpack landfill. After the NRC approved TI's decommissioning plan, the company removed about 68,000 cubic feet of contaminated soils containing high volume, low radioactivity waste, and sent it to Envirocare in Utah during 1992 and 1993. NRC is expected to complete its confirmatory survey in December, 1993. If the site is able to be released for unrestricted use, that event is scheduled to occur around March, 1994.
Wyman-Gordon	Grafton	Groundwater contamination, Ingestion	Wyman-Gordon, a metal-forging company, was licensed by the AEC to use thorium and uranium from 1958-1971. During this period, about 50,000 pounds of magnesium-thorium alloy, containing 3% thorium, was disposed of by burial in a section of company property. In 1983-1984, W-G conducted a groundwater sampling program in vicinity of disposal area. W-G and Commonwealth of MA concluded that no hazard existed to public water supplies. In September, 1990, a newspaper article questioned the safety of the disposed materials. Water sampling was conducted again, with conclusion that no current public health threat exists to drinking water wells In the area. In January, 1991, NRC asked W-G to provide a dose assessment of the disposal area. W-G responded that it would not perform a dose assessment, but would provide any available data to the NRC. In February, 1993, NRC completed a draft dose assessment that suggests future doses will exceed 1,000 millirem/year. W-G is in the process of remediating the site.

[1] Statements quoted from NRC's Site Decommissioning Management Plan, NUREG-1444, October, 1993.

Sources: U.S. Nuclear Regulatory Commission. Site Decommissioning Management Plan. NUREG-1444, Washington, DC, October, 1993. Conversations with site managers, others at U.S. Nuclear Regulatory Commission, U.S. Environmental Protection Agency, Region 1 (Boston), and Massachusetts Department of Environmental Protection, 1991-1993.

14.4 Decommissioning Methods

Three means of decommissioning a facility are authorized by the NRC regulations, and are described in guidance documents Intended to aid licensees in the decommissioning process. Their acronyms are "DECON," "SAFSTOR," and "ENTOMB."

DECON. This decommissioning method allows release of the facility and site for unrestricted use and license termination shortly after radioactive materials use has ended, which could range from a few months for a small licensee up to six years for a utility plant. DECON involves removing or decontaminating the structures, equipment, and parts of the facility that are radioactively contaminated. Non-radioactive portions of the location do not have to be removed or torn down as part of the decontamination procedure.

NRC studies identify DECON as the fastest of the three decommissioning methods. As such, because little time has elapsed for radioactive decay, it results in occupational radiation exposures that are usually higher than for the other two decommissioning methods. In addition, larger amounts of radioactive waste result from this method, because little or no waste has been stored for decay to reduce the level of radiation.

The major advantage of DECON is that it removes residual radioactivity from the site, and allows the facility to be available for some other use relatively quickly.

SAFSTOR. Three principal elements are involved in this decommissioning method. They are (1) a short period of planning and preparation, (2) a variable storage period of continuing care involving surveillance, security, and maintenance, and (3) a short period of deferred decontamination.

Three subcategories of SAFSTOR -- "custodial," "passive" and "hardened" -- are utilized for decommissioning facilities. The relationship of various facility activities for each type Is summarized in Table 14-3.

The maximum period of SAFSTOR storage is set at 60 years in the NRC's nuclear-powered utility plant regulations. The NRC must approve the safe storage period, and will allow an extension beyond 60 years only when necessary to protect the public health or safety, considering such factors as:

- the lack of waste disposal facilities;
- the presence of other nuclear facilities at the site; and
- other site-specific reasons affecting the licensee's capability to complete decommissioning safely. [10 CFR 50.82]

The third step in SAFSTOR, namely deferred decontamination, could amount to as little as a radiation survey to verify the absence of radioactivity, to as much as dismantling and removing residual radioactive materials (as is the case of the activity at the Army Materials Technology Laboratory, Watertown Arsenal). In some cases, radioactive materials in safe storage may have decayed to levels low enough to permit the facility to be released for unrestricted use without additional decontamination. In other cases, such as that of a nuclear utility plant that has operated for all or the majority of its license (30-40 years), plant materials contain various amounts of long-lived radioisotopes such as Carbon-14, Nickel-63, Niobium-94 and Nickel-59. A storage period will have a negligible effect on the radioactive decay of these materials. Carbon-14 has a 5,730 year half-life; Nickel-63 has a 96 year half-life, Niobium-94 has approximately a 20,000-year half-life, and Nickel-59 has a half-life of 75,000 years. Varying amounts of these materials accumulate as activation products in the reactor vessel internals of a long-operating power reactor.

Table 14-3 Elements and Facility Status of Decommissioning Methods			
Decommissioning Method	**Specific Activities**	**Facility Status**	**Use of Facility/Site**
DECON	Decontamination or removal to levels permitting unrestricted use of the facility	Equipment - removed if radioactive Continuing Care Staff - none Security - none Environmental Monitoring - none Radioactivity - removed Surveillance - none Structures - removal optional	Unrestricted use of facility and site after reaching permissible levels
SAFSTOR	Custodial Safe Storage	Equipment - some operating Continuing Care Staff - some required Security - continuous Environmental Monitoring - continuous Radioactivity - confined Surveillance - continuous Structures - intact	Safe storage must be followed by decontamination or removal to allow unrestricted use; facility and site continue as "nuclear"
SAFSTOR	Passive Safe Storage	Equipment - none operating Continuing Care Staff - optional on site for routine inspections Security - remote alarms Environmental Monitoring - routine periodic Radioactivity - immobilized Surveillance - periodic Structures - intact	Facility: continues as "nuclear" Site: conditional non-nuclear
SAFSTOR	Hardened Safe Storage	Equipment - none operating Continuing Care Staff - none on site Security - hardened barriers, fencing, posting Environmental Monitoring - infrequent Radioactivity - hardened sealing Surveillance - infrequent Structures - partial removal optional	Facility and site: conditional non-nuclear
ENTOMBMENT	Entombment	Equipment - some removed; some encased in concrete Continuing Care Staff - none Security - hardened barriers Environmental Monitoring - infrequent Radioactivity - encased in concrete Surveillance - infrequent Structures - intact	Facility: unusable for an extended period of time; Site: available for unrestricted use

Source: U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research. Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities. NUREG-0586, Washington, DC, August, 1988.

Advantages, Disadvantages

The advantages of SAFSTOR over DECON include minimizing both radiation exposure to workers at the site and to the public, no immediate need for waste disposal capacity, and less future disposal capacity requirements. There are also savings in initial expenses to prepare the site for storage rather than to decontaminate immediately, but these economies would likely be offset by the costs of on-going surveillance and security, necessary to ensure public protection. Such surveillance and security may be accomplished through the use of part-time staff and full-time electronic equipment, although the presence

of stored spent nuclear fuel will require greater security measures. In addition, maintenance will necessitate some personnel.

The major disadvantage of SAFSTOR is the fact that radioactive contamination remains on site. Other drawbacks include the possible unavailability of trained personnel knowledgeable about the site when deferred decontamination is ready to start;[8] the need for, and costs of, on-going maintenance, surveillance, and security; the unavailability of the site for other uses; and the possibility that regulatory requirements may change during safe storage.

The NRC has expressed the opinion in its Generic Environmental Impact Statement (GEIS) on the decommissioning of various radioactive materials user facilities, that a 30-year period of safe storage, followed as part of the SAFSTOR decommissioning option, appears to be reasonable for the decommissioning of both types of light water reactor utility plants (PWR and BWR):

> "Generally, the purpose of SAFSTOR is to permit Cobalt-60[9] to decay to levels that will reduce occupational radiation exposure during decontamination....Most of the occupational dose reduction due to decay occurs during the first 30 years after shutdown with considerable less dose reduction thereafter. The public dose, which will always be small, will also experience most of its reduction during the first 30 years."

The NRC report does not find a 100-year SAFSTOR storage period "reasonable" because it results in the continued presence of a radioactively-contaminated site with little benefit in "aggregate dose reduction compared to 30-year SAFSTOR."

In addition, the volume of LLRW requiring disposal is generally less for SAFSTOR than DECON due to the decay of radioactivity of the waste during the safe storage period. This benefit may not be a compelling one to the licensee in selecting a decommissioning alternative.

Of the commercial nuclear power reactors that have ceased operating, the SAFSTOR decommissioning method has, to date, been chosen almost twice as often as the DECON method. Both, however, are viewed by NRC as reasonable alternatives for decommissioning these types of nuclear facilities.

Since it closed prior to the end of its licensed operational period, Yankee Atomic Electric Company, operator of the Rowe plant, has been preparing the formal "decommissioning plan" for submission to the NRC. In the interim, the company has removed several large reactor components and other LLRW, while the Commonwealth still has access to the Barnwell, South Carolina, disposal site.

One reactor in Massachusetts has been involved in the SAFSTOR method of decommissioning since the early 1970s. The U.S. Army's small research reactor at the Watertown Arsenal completed its second phase with the conclusion of 20 years of safe storage in the early 1990s. Final decommissioning is being completed, with the plans of having the site released for unrestricted use in the mid-1990s. The total amount of waste resulting from this decommissioning is 154,000 cubic feet. The Army shipped this waste to the Envirocare of Utah disposal site, which accepts high volume, low-activity soils and rubble.

ENTOMB. The third decommissioning method is the alternative that allows radioactive contaminants

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[8] This potential problem could be offset by extensive documentation of all decommissioning activities.

[9] Cobalt-60 has a half-life of only 5.27 years. However, it is considered an intense gamma emitter, and can cause serious biological effects to an exposed person.

to be encased in a structurally-rigid and long-lived material, like concrete, until radioactivity decays to a level that allows release of the property for unrestricted use. This method is not considered appropriate for nuclear power plants that have operated for extensive time periods, due to the presence of the same long-lived isotopes mentioned in the SAFSTOR option.

The advantages of the ENTOMB method are the reduction of worker and public exposure to radiation. The disadvantages are the same as those identified for SAFSTOR.

In addition, the NRC suggests in its GEIS report on decommissioning that the ENTOMB method may necessitate all the licensing considerations required in its LLRW disposal regulations, 10 CFR Part 61.

14.5 Decommissioning Regulations

As noted, the level of decommissioning activities required by NRC depends upon the quantities and types of radioactive materials used, and the extent of radioactive contamination. For example, only certain types of radioactive materials licensees are required to submit decommissioning funding plans as a part of their license applications. All licensees must submit such a plan upon application for license termination.

This section summarizes the principal decommissioning requirements for all types of licensed users.

Record-Keeping

All licensed users of radioactive materials in Massachusetts are required to keep records of information important to the safe and effective decommissioning of their sites, until their license is terminated by the NRC. According to NRC regulations, information the Commission considers important to decommissioning consists of:

- records of spills or other unusual occurrences involving the spread of contamination in and around the facility, equipment or site, including the identities of the radionuclides involved, their quantities, forms, and concentrations;

- drawings and modifications of structures and equipment in restricted areas where radioactive materials are used and stored, and of locations of possible inaccessible contamination such as buried pipes that may be subject to contamination; and

- records of the cost estimate conducted to develop a decommissioning funding plan, or of the amount certified for decommissioning, and other records pertaining to financing the decommissioning activities.

In December, 1992, the NRC announced in the Federal Register its intention to adopt new regulations to aid the agency in identifying potential radiation-related problems and to ensure the total completion of decontamination and decommissioning. The draft regulations would require all licensees to prepare and maintain additional documentation besides those that are already required, identifying:

- areas where licensed materials and equipment were stored or used outside restricted areas;[10]

[10] A restricted area is any area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.

- areas where spills have occurred;
- locations and contents of current and previous burial areas within the site; and
- equipment involved in the licensing activity that will remain on site at the time of license termination.

Financing Plans

Only certain applicants are required to submit, along with their license application, a plan for the methods of financing their decommissioning activities in order to receive a license to possess and use radioactive materials. This decommissioning funding plan requirement applies to:

(1) any radioactive materials user licensed to possess and use unsealed byproduct material that has a half-life greater than 120 days and in quantities exceeding 100,000 times the limits set by the NRC in Appendix C of 10 CFR Part 20. [10 CFR 30.35][11] This requirement may apply to licenses authorized under 10 CFR Parts 30, 32-35, and 39 for medical research, the manufacture of various products, and the use of radioactive materials in educational and health care settings;

(2) any radioactive materials user licensed to possess and use quantities of source material[12] greater than 10 millicuries [10 CFR 40.36];[13]

(3) any application for a license to operate a nuclear-powered utility plant [10 CFR 50.33(k)(1)];

(4) any radioactive materials user licensed to possess and use unsealed special nuclear material in quantities exceeding 100,000 times the limits set in 10 CFR Part 20, Appendix C [10 CFR 70.25];[14] and

(5) any application for a license for independent storage of spent nuclear fuel and high level

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[11] "Byproduct material" is any radioactive material except special nuclear material that is yielded in or made radioactive by exposure to the radiation incident to the process of producing or using special nuclear material. Part 20 of the NRC regulations contains standards for protection against radiation. Appendix C of Part 20 sets limits for numerous radionuclides that trigger certain regulatory requirements, such as decommissioning. For example, the limit in Appendix C for Calcium-45 is 10 microcuries. Since Calcium-45 has a half-life of 165 days (i.e., greater than the 120-day requirement for decommissioning), a licensee who possesses more than one curie (one million microcuries equals one curie) of this radionuclide is required to provide a decommissioning funding plan.

[12] "Source material" means (1) uranium or thorium, or any combination of these two elements in any physical or chemical form, or (2) ores containing by weight 0.05 percent or more of uranium, thorium or their combination. Source material does not include "special nuclear material."

[13] A "millicurie" (mCi) equals one thousandth of a curie.

[14] "Special nuclear material" means (1) plutonium, uranium 233, uranium enriched in the isotope 233 or 235, or any other material which the NRC has placed under this definition; or (2) any material artificially enriched by the above materials, but not including "source" material. Users of special nuclear material licensed under Part 72 involve academic, medical, biological, agricultural, military, and industrial applications such as nuclear power plant fuel processing and fuel fabrication.

radioactive waste at either an "independent spent fuel storage installation" (ISFSI), or at an MRS facility. [10 CFR 72.30][15]

Each decommissioning funding plan must contain a cost estimate for decommissioning and a description of the method of assuring that funds will be available when decommissioning begins. In the case of group (1) above – i.e., the "byproduct material" users licensed under 10 CFR 30, 32-35, and 39, as well as certain licensed users of "source" material in a readily dispersible form (group (2) above), and certain licensees of "special nuclear" material (group (4) above), – the funding plan for decommissioning may be substituted with a "certification" of financial assurance that funds will be available for decommissioning. [10 CFR 30.35, 10 CFR 40.36 and 10 CFR 70.25]

Regardless of whether the NRC allows certification or requires funds to be periodically set aside for decommissioning, the agency's regulations require that financial assurance be provided by one or more of the following methods:

- prepayment in the form of a trust, escrow account, government fund certificate of deposit, or deposit of government securities, prior to the start of operation, through a deposit in an account segregated from licensee assets and outside licensee administrative control;

- a surety bond, letter of credit, or line of credit by a parent company, or insurance to assure that the decommissioning would be funded even if the licensee should default;

- an external sinking fund in which deposits are made at least annually, coupled with a surety method or insurance to make available enough money to guarantee decommissioning in the event a facility closed prematurely; and

- in the case of federal, state or local government licensees, a statement of intent containing a cost estimate for decommissioning or an amount based upon the quantity of radioactive material used by the licensee.

The NRC has established minimum amounts of financial assurance for decommissioning, based upon the quantities of radioactive materials authorized for use. These amounts are:

- For "Part 30" byproduct materials users, a range between $75,000 and $750,000 [10 CFR 30.35(d)];

- For "Part 40" users of source materials in a readily dispersible form, a range between $150,000 and $750,000 [10 CFR 40.36]; and

- For "Part 70" licensees of unsealed source material, a range between $150,000 and $750,000. [10 CFR 70.25]

Each level must be adjusted periodically over the life of the facility, to ensure that actual dollar amounts will equal current costs.

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[15] An ISFSI may be built at a nuclear power plant, or built off site. An ISFSI requires a separate license from that of a nuclear power facility, and therefore requires separate decommissioning actions. Both ISFSI and MRS facilities are licensed by the NRC.

Funding Plans for Utility Power Plant Decommissioning

The financial assurance requirements for nuclear-powered electric utility companies licensed under "Part 50" of the NRC regulations are similar to, but more stringent than, those summarized above. Financial assurance for utilities may be provided by prepayment, an external sinking fund or surety method, or Insurance. In utilizing a surety method, however, the utility company may not provide financial assurance through the use of a parent company guarantee of funds, as Is allowed for "Part 30," "Part 40," and "Part 70" licensees.

As part of their license application, nuclear-powered electric utilities must submit a decommissioning report containing a certification that funds will be available for decommissioning. A minimum level of utility plant decommissioning funding is set by NRC regulations based upon decommissioning costs of each type of reactor and power level.[16]

Based on this minimum, Yankee Rowe decommissioning costs in 1991 dollars would be $108,900,000 and Pilgrim Station, $155,260,000 assuming only an inflationary adjustment. NRC officials explain that the minimums in their regulations are merely used as a guide, and are not the true total costs of decommissioning. For example, when Boston Edison submitted its required initial decommissioning financing plan, it calculated its costs to be $87,324,000 (1982 dollars). Boston Edison's latest projection submitted to the NRC in 1991 is for a decommissioning cost of $327,844,000. Yankee Atomic Electric has estimated that its total decommissioning costs for the Yankee Rowe plant would approach $247 million dollars. This latest estimate includes $32.7 million to maintain the plant until the year 2000, when Yankee expects dismantling will begin; and $56.5 million to construct an on-site dry-cask storage facility for its spent fuel.

The NRC does not include the removal of spent fuel from the facility or the storage of spent fuel on-site as part of "decommissioning" for purposes of calculating the financial requirements of decommissioning. Spent fuel removal from a nuclear powered facility is considered an "operational" activity; as mentioned, spent fuel storage may remain on-site for 30 years after the expiration of the reactor operating license.[17]

Yankee Atomic reported that its decommissioning fund contained approximately $102,000,000 at the end of 1993. Boston Edison reported a fund of $68,000,000 at the end of November, 1993, for its decommissioning of Pilgrim, scheduled at the current time to begin in the year 2012, when its operating license expires.

Funding Plans for ISFSI Decommissioning

The financial assurances that must be submitted with an application for an independent spent fuel

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[16] The main type of reactor operating in the United States is called a "light water reactor," named because it uses ordinary water within the reactor for two major functions: (1) as the "coolant" to reduce the heat of the fission process, and (2) as the material in which the neutrons collide and slow down. Two types of light water reactors are in use. The "boiling water reactor" (BWR) produces steam through some boiling at low pressure. The "pressurized water reactor" (PWR) operates at high pressure without boiling. In Massachusetts, the nuclear-powered plant in Plymouth is a BWR, and the Rowe plant was a PWR.

[17] Even though a nuclear power plant operating license may have expired, the NRC will not terminate the license if any spent fuel or other waste remains on site. This way, the power plant operator continues to be liable for conditions at the site. As noted, the utility company could store spent fuel on site under its existing "Part 50" license in NRC-approved dry storage units. Or, the licensee could apply for a "Part 72" storage license.

storage installation (ISFSI) licensed under 10 CFR 72 are identical to those required for Part 30 licensees. NRC regulations do not set a minimum amount necessary for ISFSI decommissioning. However, as part of a "Part 72" decommissioning plan, the NRC must agree on the level of decommissioning funding.

Decommissioning for License Termination

Every radioactive materials licensee must complete a decommissioning strategy in order to have the license terminated by the NRC. The requirements for decommissioning preparations in connection with license termination vary with the types of licenses: 10 CFR Parts 30, 32-35, 40, 70, and 72 licensees must follow similar rules. "Part 50" nuclear power plant licensees have much more stringent requirements.

When any licensee decides to cease all activities involving the use of radioactive materials, the licensee must submit a written notice to NRC requesting license termination. This request must include information about the disposition of radioactive material and waste remaining on site, and the results of a radiation survey of the premises.

In addition, if decommissioning procedures were not previously approved by the NRC and they could increase the potential health and safety impacts to workers or to the public, the licensee must submit a decommissioning plan. Decommissioning activities that the NRC believes could increase the potential health and safety impacts include:

- procedures involving techniques not routinely used during clean-up or maintenance;
- workers having to enter areas not normally occupied, where surface contamination and radiation levels are significantly higher than routinely encountered during operation; and
- procedures that could result in significantly greater airborne concentrations or releases of radioactive materials to the environment than are present during licensed operations.

The proposed decommissioning plan must include descriptions of:

- planned decommissioning activities;
- methods used to assure protection of workers and the environment against radiation hazards during decommissioning;
- the planned final radiation survey; and
- an updated, detailed cost estimate for decommissioning, comparing that estimate with funds currently set aside, and assuring the availability of revenues to complete decommissioning.

In order to complete decommissioning, so that the license can be terminated, a licensee authorized under 10 CFR Parts 30, 32-35, and 40 must properly prepare for disposal of all radioactive material and waste, show that a "reasonable effort" to eliminate residual radioactive contamination, if present, has been completed, and perform a radiation survey that confirms that the premises are suitable to release the site for unrestricted use. [10 CFR 30.36(f) and 10 CFR 40.42(f)] A licensee authorized under "Part 70" to use unsealed special nuclear material must conduct a second radiation survey and certify the disposition of all waste accumulated from decommissioning. [10 CFR 70.38(c)(3)]

Even if the date of a license expires, it is not terminated by the NRC with respect to the licensee's responsibility over all residual contamination on site until the NRC notifies the licensee in writing that the license is terminated. During this period, the licensee is required to:

- limit actions involving the use of radioactive material to those related to decommissioning, and

- continue to control entry to restricted areas (unless they are suitable for release for unrestricted use according to the standards set in 10 CFR Part 20) and unless the license has been terminated by the NRC.

Additional Requirements for Utility Decommissioning

Nuclear power plant licensees must submit a second decommissioning plan besides the one submitted by all other types of licensees. Approximately five years prior to the end of operations, a nuclear-powered utility must file with the NRC a "preliminary decommissioning plan." This plan must include a cost estimate for decommissioning (updated since the filing of the decommissioning funding plan necessary for license approval), and an assessment of the "major technical factors" that could affect plans for decommissioning. [10 CFR 50.75(f)] These factors include:

- the decommissioning alternative anticipated to be used, such as DECON or SAFSTOR (the ENTOMB method would not likely be approved);

- the major technical activities necessary to conduct safe decommissioning;

- the status of LLRW and HLRW disposal;

- criteria for handling residual radioactivity; and

- other site specific factors that could affect decommissioning planning and costs.

The second decommissioning plan required of utility nuclear powered plants undergoing license termination is called the "proposed decommissioning plan," and must be submitted within two years following permanent cessation of operations, but in no case later than one year prior to the expiration of the "Part 50" operating license. The proposed decommissioning plan must include:

- the choice of decommissioning alternative. The NRC allows decommissioning to be completed within 60 years. This means that either DECON or SAFSTOR are available to nuclear utility plants.

- a description of controls and limits on procedures and equipment that will be established in order to protect plant workers and public health and safety;

- a description of the planned final radiation survey;

- an updated cost estimate for the chosen decommissioning alternative, a comparison of that estimate with the amount of funds currently set aside for decommissioning, and a plan for assuring the availability of any remaining funds necessary to complete decommissioning; and

- a description of technical specifications, quality assurance, and physical security plan provisions that will be utilized during decommissioning.

NRC will terminate the power plant "Part 50" license if it determines that the decommissioning has been completed in accordance with the approved decommissioning plan, and the terminal radiation survey and related documentation demonstrates that the facility and the site are suitable for release for unrestricted use. [10 CFR 50.82(f)]

As can be surmised from these added requirements, the decommissioning of a nuclear-powered electric plant is a more significant action than the decommissioning of other types of licensed radioactive materials users' facilities. The fact that decommissioning must address the quantities of LLRW present on site, and spent nuclear fuel may have to remain at the site due to the lack of disposal facilities for these materials, raises understandable concerns that decommissioning activities be performed in a manner that best protects the public's health and safety.

NRC regulations provide methods by which these concerns can be addressed. Individuals or groups may request inspection of decommissioning documents [10 CFR 50.39], and may also petition to intervene as a party to the proposed decommissioning activity. [10 CFR Part 2]

The NRC requirements for decommissioning and license termination summarized above do not contain generally applicable radiological criteria for decommissioning. Aware of this problem, NRC issued a Federal Register notice in December, 1992, regarding its "Enhanced Participatory Rulemaking on Radiological Criteria for Decommissioning." In 1993, NRC conducted workshops across the country (including one in Boston which Management Board staff attended), to receive comments on this issue from state officials, professional societies, citizens, and environmental and other interested groups. NRC staff are preparing a Generic Environmental Impact Statement to accompany its proposed new regulations, which is scheduled to be submitted to the Commission in April, 1994. The draft rule would be issued for public comment in mid-1994, and the final rule would be adopted in mid-1995.

14.6 Waste Management Implications and Recommendations Regarding Decommissioning

Decommissioning activities have direct impacts upon Massachusetts' responsibility for LLRW management and disposal. This section summarizes those impacts, and suggests certain actions to protect the Commonwealth's interests in protecting public health, safety, and the environment.

Impacts on Disposal Responsibility. As noted, federal law directs all states to assume responsibility for LLRW management and disposal, beginning Jan. 1, 1993. Federal law also allowed South Carolina, Nevada and Washington, the three states which, up until December 31, 1992, had accepted waste at their disposal sites from LLRW generators all across the country, to deny access to all LLRW producers in the nation except those generators whose states are members of the sited states' compact regions.[18] The Nevada site ended all operations; the Washington site ceased accepting waste from Massachusetts; South Carolina agreed (by contract with the Management Board and the Southeast Compact Commission) to accept Massachusetts-produced LLRW through June 30, 1994.

As a result, after June, 1994, all LLRW generated in Massachusetts (and in numerous other states) may have to be stored on site until a disposal facility is available. The State's responsibility for LLRW disposal, beginning in 1993, includes the LLRW produced as a result of decommissioning the Yankee Rowe plant and Boston Edison's Plymouth plant (estimated to be initiated after the year 2012, when the Boston Edison license expires), as well as the decommissioning of other large waste-generating Massachusetts licensees' facilities.

Decommissioning activities at the Rowe plant are estimated by Yankee Atomic Electric Company to generate 95,000 cubic feet of LLRW, containing approximately 192,000 curies of activity. This volume and

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[18] Chapter 6 discusses existing LLRW regional compacts.

activity is broken down by NRC waste disposal class as follows:

- 92,600 cubic feet of Class A, containing 3,400 curies;
- 1,000 cubic feet of Class B, containing 10,900 curies; and
- 1,300 cubic feet of Class C,[19] containing 177,900 curies.

Table 14-4
Facts about Yankee Rowe and Pilgrim Station

Yankee Rowe is the oldest nuclear power plant in the country, and the second smallest. The generating capacity of all nuclear power plants ranges from 67 megawatts of electric power to 1270 megawatts. Some statistics on the Rowe and Plymouth plants:

	Rowe	Plymouth
Total Site Area	2,000 acres	517 acres
Licensed	1960	1972
Licensee	Yankee Atomic	Boston Edison
License expiration	2000	2012
Electricity Rating[a]	175	655
Type[b]	PWR	BWR
Cooling System[c]	OT	OT
Cooling water source	Deerfield River	Cape Cod Bay
Intake Structure	Sherman Pond[d]	Edge of Bay
Discharge Structure	Sherman Pond	850-foot canal

[a] Measured in megawatts of electric power - (MWe)
[b] PWR, Pressurized Water Reactor; BWR, Boiling Water Reactor
[c] A "once-through" (OT) cooling system circulates water drawn from an adjacent water body through the condenser tubes and back (at higher temperatures) to the water body. Waste heat dissipates to the atmosphere primarily by evaporation from the body of water.
[d] 90 feet below the surface of Sherman Pond.

Source: U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research. Generic Environmental Impact Statement for License Renewal of Nuclear Plants. (Draft) NUREG-1437, Vol. 1, Washington, DC, August, 1991.

This decommissioning LLRW is expected to be generated over an 18-month period once dismantlement commences. Yankee Atomic believes the maximum amount of LLRW that will be generated in a 12-month period will be 60,000 cubic feet. This amount is significantly higher than the average annual volume of LLRW shipped for disposal by Yankee in recent years. From 1989 to 1991, Yankee shipped for disposal a yearly average of 7,537 cubic feet, of which 99% was Class A, 0% was Class B, and 1% was Class C. Similarly, 97.5% of the decommissioning LLRW is expected to be Class A, 1.1% Class B, and 1.4% Class C. If Yankee Rowe had continued to operate through the end of its license (about eight more years), approximately 60,000 cubic feet of LLRW would have been generated from normal operations. If the plant had obtained a license extension to operate beyond the original license period for an additional 10 years, about 136,000 cubic feet of LLRW would have been generated during that time.

Yankee is currently executing a project to remove several reactor components, which would reduce the final total of LLRW requiring disposal after dismantlement to approximately 80,000 cubic feet containing less that 10,000 curies of activity.

Assuming either the higher or lower volume of Yankee Rowe decommissioning LLRW, and assuming it would be available for disposal over a two-year period during dismantlement, the Yankee LLRW volume represents three to four times the volume of all other LLRW expected to be generated during that period. Massachusetts LLRW producers are currently generating about 43,000 cubic feet a year which requires disposal in a licensed LLRW disposal facility. However, based on estimates supplied by the generators in the Management Board's annual survey, waste production is expected to drop and level off at about 20,000-25,000 cubic feet a year by 1995. (This estimation does not include the 288,000 cubic feet (and 1,695,645 curies) of Plymouth power plant waste expected to be generated from the decommissioning of that facility around 2012, which is not factored into the 20,000-25,000 cubic feet per year volume, because of the uncertainty of plans almost 20 years in the future. This volume is incorporated into estimates for any in-state

[19] Please refer to the explanation of the NRC classification system in Chapter 7.

disposal facility, however.)[20]

Impact from Insufficient Decommissioning Funds. As was noted earlier in this chapter, large costs are involved in the decommissioning of a nuclear power plant. Because the plant in Rowe ceased operation eight years before the expiration of its license, the full amount necessary for decommissioning had not been raised. Yankee Atomic is pursuing various avenues to acquire additional decommissioning revenues. The Commonwealth should monitor those efforts closely, since failure to provide decommissioning funding leaves no alternative revenue source to ensure the safe and environmentally-sound decommissioning of this property.

Impacts on Negotiations with Other States. With the exception of nuclear power plant decommissioning, decommissioning activity in Massachusetts from past or current radioactive materials users, or from illegal, unlicensed disposal sites, is unlikely to generate the quantity and types of long-lived radionuclides that are problematic for disposal. These types of decommissioning, therefore, to date have had little or no effect on discussions held by Massachusetts with other states about the possibility of Massachusetts LLRW generators using those states' new disposal facilities.

However, the announcement by Yankee of its initiation of plans for immediate decommissioning has had a negative effect upon discussions between Massachusetts and some other states developing new disposal facilities. Because LLRW disposal is an extremely controversial and sensitive subject, states that are planning disposal facilities anticipate significant political and public opposition to the acceptance of nuclear power plant decommissioning waste. As the discussions in Chapter 6 (Regional Compacting) and Chapter 15 (Need for Additional Facility Capacity) indicate, some states are statutorily prohibited or politically unwilling to accept LLRW from outside their compact regions.

Significant amounts of long-lived radioisotopes are expected to be found in nuclear power plant decommissioning LLRW. While some observers believe that "LLRW is LLRW, no matter where it was produced," many citizens around the country are especially combative over the idea of allowing long-lived isotopes, particularly those that result from nuclear power plant decommissioning, to be disposed of in their facilities from plants outside their state or region.

Impacts from Waste Handling. Decommissioning waste will be produced from facility structures and components, and handled and processed in a series of procedures that will expose workers to various sources of radiation. Waste already placed in containers for storage or disposal before decommissioning begins will require preparation for shipment; waste generated as a result of decontamination and dismantlement operations will require packaging for storage or shipment. Some wastes will be processed to reduce volumes or enhance waste characteristics for storage and disposal. Waste handling and processing potentially increases the risk of accidents, radiation releases, errors, or other incidents.

Impacts from Waste Packaging. Because waste disposal is not likely to be available for several years after June, 1994 -- the date currently scheduled for access to cease at Barnwell, South Carolina -- LLRW will have to be stored on site. Any decommissioning activity involving the packaging of waste for storage and ultimate disposal will have to consider whether the waste should be packaged for temporary storage -- in order to allow further waste treatment at a later date, or whether it should be packaged for final disposal -- thereby making the waste less amenable to later treatment.

Whatever decisions are made regarding waste packaging for storage, treatment, or disposal, the

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[20] It is estimated that the LLRW resulting from the decommissioning of Pilgrim Station in Plymouth will be predominantly Class A, with less than 25% Class B and about 1% Class C, all containing a total of about 1.7 million curies.

quantity of waste and activity in the package, and the type of container into which it is placed, may require modification prior to final disposal in order to meet whatever disposal criteria are established when new facilities open in the future. The potential uncertainties of waste packaging, and the possibility of repackaging, have financial implications to the LLRW generators and to the Commonwealth.

Impacts from Interim Storage during Decommissioning. As a condition of their NRC licenses, LLRW generators are required to ensure that all waste held in interim storage -- either on site or at a licensed commercial storage facility -- is stored under conditions adequate to protect the environment, and the health and safety of workers and the public. If South Carolina fulfills its current pledge to close off access to Massachusetts' (and other states') generators in June, 1994, interim storage arrangements will be required for all LLRW, both waste from radioactive materials operations, and waste from decontamination and decommissioning. Costs of packaging and storing waste on site may divert resources away from essential benefits provided to society through the use of radioactive materials. In addition, some old burial sites undergoing decommissioning and mitigation plans, may not be willing or able to store this waste on site, while awaiting a disposal solution.

Although regulatory constraints and proper precautions limit potential incidents and consequences, storage of large quantities of LLRW carries with it potential increased risks to workers and the public, particularly under certain accident conditions, such as fire. The Commonwealth will need to have continued assurances that all waste is being stored in the appropriate methods throughout the period of interim storage. Assurances should come from the certified responses to the Management Board's annual survey, as well as routine site visits.

Because nuclear power plant decommissioning is the regulatory responsibility of the NRC, not state government, the chief regulatory interplay will occur between the nuclear utility company and the federal government, not the State. Once Massachusetts becomes an Agreement State, the Commonwealth should develop an agreement with each nuclear utility providing state personnel access to the interim storage facilities developed for both decommissioning and non-decommissioning waste.

Impacts from Radiation Dose to Workers and the Public. In general, while decommissioning activities can cause radiation exposure to workers in a facility, the exposure levels should continue to be within the range of federally-accepted standards, and can be controlled and reduced through the use of protective clothing, equipment, and procedures.

Decommissioning is not expected to affect public exposure significantly. Although the impacts are calculated to be small, nuclear power plant decommissioning presents a potentially greater risk to the public due to the differences in the scale of activities involved in power reactor decommissioning and the significant differences in the quantities of radioactivity being processed at these facilities.

There are three principal radiation exposure pathways potentially involved in the decommissioning of a nuclear reactor such as the Rowe plant: inhalation, ingestion, and external exposure to radioactive materials. The workers employed in decommissioning activities can be protected from exposure through inhalation and ingestion by the use of protective clothing and equipment. Their chief exposure pathway will be from external exposure.

While decommissioning activities are underway, the dominant pathway of exposure to the public is inhalation, since external exposure and exposure through ingestion can be minimized or even eliminated through various decommissioning techniques.

Once the decommissioning wastes are shipped off site, the major pathway for potential radiation exposure to the public during transport is external exposure. Inhalation and ingestion of radioactive materials can be minimized or eliminated during transport through the use of various protective measures.

Regardless of the potential for occupational and public exposure to radiation, studies of past nuclear power plant decommissionings have led the NRC to conclude that commercial nuclear reactors like Yankee Rowe can be decontaminated and decommissioned with "reasonable" occupational radiation exposure and "virtually no" public exposure. Decommissioning to date has occurred primarily to small, demonstration reactors, such as the facility at Elk River, Minnesota, a boiling water reactor that had a rating of only 22 megawatts, electric.[21]

The Yankee Atomic Electric Company, responsible for the decommissioning of the Rowe power plant, intends to use the DECON method followed by immediate dismantlement. For purposes of ensuring the protection of workers and the public during the decommissioning of Yankee Rowe and Pilgrim Station, the Commonwealth needs to monitor the development of decommissioning plans and work with the NRC to confirm that decommissioning techniques are planned and implemented to keep radiation exposures as low as reasonably achievable.

Impacts from the Transportation of Decommissioning Waste. Because packaging requirements for the transportation of decommissioning waste are the same as those required for the shipment of other radioactive materials and LLRW,[22] the impacts on the Commonwealth's ability to manage LLRW from the transportation of decommissioning waste are no different from the Commonwealth's concern over LLRW shipments in general. Most decommissioning LLRW will be disposal Class A waste, with substantially lesser amounts of Class B and Class C.

For the smaller volumes of high activity LLRW, the various state agencies responsible for enforcing transportation regulations should be alerted when a shipment of this material is transported over the road network of the Commonwealth. These shipments must be transported with enhanced control and security mechanisms and procedures from their point of departure to the end of their trip. It is recommended that such shipments have back-up drivers to eliminate any need to stop at night, so that shipments can proceed expeditiously and at times of lower traffic densities. (See discussions and recommendations to enhance safe LLRW transportation, in Chapter 9 of this volume.)

Impacts on the Environment. The potential for radiation contamination to occur to the land, water or air exists in connection with radioactive materials use, in the same way that the potential exists for the environment to be threatened by the use of other products in an industrial society. For example, toxic chemicals, if improperly controlled, can lead to environmental damage. So, too, can the misuse and improper disposal of certain household cleaning supplies. Because society has determined that the benefits of using these products and materials outweigh the potential harm, these and other materials are regulated by federal, state, and local governments in various degrees according to their potential for environmental harm, in order to ensure their proper, safe utilization.

This chapter has summarized the principal regulatory provisions associated with decommissioning. If decommissioning activities are conducted properly, the potential for environmental harm is slim. If decommissioning is not accurately implemented, the potential exists for environmental damage to occur. Experience with decommissioning various types of licensed facilities -- sites of both small and large radioactive materials users -- has not demonstrated significant environmental effects.

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[21] ELK River was decommissioned between 1971 and 1974. The containment structure was kept intact until the pressure vessel and the biological shield were extracted, and all radioactive metal and concrete was removed. The use of remote-controlled state-of-the-art metal cutting enabled occupational exposures to be kept to a minimum.

[22] Please refer to the discussion of packaging and shipping requirements in Chapter 9.

The net effect of decommissioning is to make property available for unrestricted use by eliminating the activity involving radioactive materials or waste, and by reducing residual radioactivity. By removing the radioactivity through decommissioning, the potential of any future environmental damage from this material's existence at a site can be eliminated or significantly reduced, which is a very positive environmental impact.

Non-radiation-related effects to the environment from decommissioning must also be considered, as is the case with the dismantlement or demolition of any facility. These include the possibility of fugitive dust, runoff, and noise. As would apply for potential radiation impacts, potential environmental impacts can be mitigated through proper planning and conduct of decommissioning activities.

The decommissioning of most locations where radioactive materials are used in the Commonwealth should not entail any greater regulatory involvement in terms of environmental inspections and reviews of written reports and surveys than would be required to monitor and enforce the regulations pertaining to continued radioactive materials use. In a few instances, like the decommissioning of the two nuclear-powered electric generating plants and other large radioactive materials users in Massachusetts like Du Pont and Nuclear Metals, the involvement by state and federal regulators is likely to be more intensive.

To a great extent, the potential environmental impacts resulting from the decommissioning of the Yankee Rowe and Pilgrim Station power plants will depend upon the decommissioning method employed at those facilities. For example, as noted by the NRC in its GEIS on nuclear-powered facility decommissioning, the environmental impacts of the ENTOMB method "could be quite high should large amounts of radioactivity escape from a breached structure during the entombment period." On the other hand, NRC also notes that, "In the cases of DECON and SAFSTOR, the environmental effects of greatest concern (i.e., radiation dose and radioactivity released to the environment) are substantially less than the same effects resulting from reactor operation and maintenance."

Land Needed for the Disposal of Decommissioning Waste

The principal environmental impact of decommissioning is the commitment of land for radioactive waste disposal and the environmental and public health monitoring that will be required for an extensive period of time. The land where a disposal facility is located will have to be dedicated to LLRW management for an extended period -- possibly for several hundreds of years -- and the facility must ensure the protection of public health and the environment pursuant to 10 CFR 61, regulations of the NRC. If the Management Board determines that a disposal facility is necessary to be sited, built, and operated within the Commonwealth, this environmental impact will relate directly to Massachusetts lands, and, in addition to the disposal requirements of the NRC and DPH, the facility will have to meet all environmentally-pertinent waste acceptance criteria established by the Management Board.

Environmental Study

In revising its regulations on decommissioning in 1988, the NRC eliminated its earlier regulatory requirement that an environmental impact study be conducted in connection with the decommissioning of certain types of facilities, such as nuclear power plants. While the NRC regulations retain the requirement that an environmental report be submitted with any application for power plant license modification prior to beginning the decontamination process, this environmental report is not the same extensive study as is required for an environmental impact statement, and would be prepared only in relation to the environmental impacts of modifying the "Part 50" license from an "operating" license to a "possession only" license. The total environmental consequences of decommissioning would not be assessed.

The NRC believes that a full-scale environmental impact statement is not necessarily needed for all nuclear-powered utility decommissionings. NRC will therefore make determinations on such a requirement

on a facility-by-facility basis.

Because the issue of an environmental Impact study is of considerable concern to many of the Commonwealth's citizens, the Commonwealth should consider whether such an environmental impact study Is necessary, and communicate its view to the NRC In a timely fashlon.

The Commonwealth should ensure that all decommissioning plans are implemented in ways that eliminate or minimize radioactive contamination of the environment. Once the State becomes an Agreement State for purposes of regulating all radioactive materials users (except commercial nuclear power plant licensees), the Agreement State agency (i.e., DPH) should assess each decommissioning event on a licensee case-by-case basis to determine the level of on-site observation and inspection necessary.

Impacts on Waste Disposal. Because decommissioning can generate large volumes of LLRW, plans for LLRW disposal using either in-state or out-of-state disposal solutions must account for the eventual decommissioning of certain nuclear facilities, especially the Yankee and Pilgrim commercial utility plants which will produce large quantities of decommissioning waste.

Decommissioning of any nuclear power plant reactor will result in LLRW and a small volume of high-radioactivity wastes from some of the internal parts In the reactor core. Much of the high-radioactivity wastes, often called "high-activity activation wastes," may be classified as Greater-Than-Class-C (GTCC) under NRC regulations, and would, therefore, be the disposal responsibility of the federal government. An Important consideration of the Commonwealth will be to monitor the utility's determination of the appropriate classification of these activation wastes.

Considerations must also be made of the types of radionuclides contained in decommissioning waste -- especially those long-lived components of Yankee Rowe and Pilgrim Station's decommissioning waste -- in connection with the design of any centralized storage or disposal facilities that may be developed In Massachusetts. In addition, requirements for segregating, monitoring, and retrieving long-lived wastes will be essential considerations in disposal facility development.

One small portion of the LLRW stream that may result from decommissioning, known as "mixed waste,"[23] has special Impacts on current LLRW management. Mixed waste must be removed from the site in order for decommissioning to be completed. However, because limited mixed waste storage, treatment, and disposal facilities are available for some mixed waste, and no facilities are available for others, mixed waste generators may have no choice other than to store this waste on site, thus delaying completion of their decommissioning plans.

DOE has indicated a potential willingness to accept mixed waste at any disposal sites it develops for federal mixed waste. However, a number of legal and regulatory impediments must be resolved before mixed waste disposal will be available.

Summary

Today, decommissioning requirements set much higher regulatory and environmental standards for the termination of activities involving the use of radioactive materials. Hopefully, the days of the "bury" and "walk-away" mentality are gone. Federal and state regulators, as well as the public, can and should work to ensure the proper application of the new decommissioning systems so that decommissioned sites are truly available for "unrestricted" uses.

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[23] Please refer to the discussion of mixed waste in Chapter 8.

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Chapter 15: The Need for Storage, Treatment, and Disposal Facilities

15.1 Introduction

Some of the low-level radioactive waste (LLRW) generated by the approximately 450 users of radioactive materials in Massachusetts[1] is stored for a couple years on the premises where it was produced while the radioactive contaminants in the waste decay to safe background radiation levels, allowing the waste to be disposed of as essentially non-radioactive, solid waste. Other LLRW, however, contains radionuclides that require longer time periods to decay to natural background radiation levels. This waste cannot be disposed of anywhere but in a licensed LLRW disposal facility. Much of the waste sent to such facilities is treated prior to disposal to achieve volume reduction, biological hazard elimination, or stability for disposal.

Of the Massachusetts-generated LLRW ultimately requiring disposal, 42,686 cubic feet in 1991 and 119,004 cubic feet in 1992, was shipped to Barnwell, South Carolina; Beatty, Nevada; Clive, Utah;[2] or Hanford, Washington, where it was disposed of in licensed LLRW disposal sites. Since January 1, 1993, all LLRW requiring disposal in a licensed disposal facility has been stored at the locations where it was generated, or has been shipped to the Barnwell or Utah disposal sites. Neither the Nevada site (which has been closed) nor the Washington site (which is limiting its acceptance of waste for disposal to two regional groupings of western states) is available to take any more LLRW from Massachusetts.

The practice of shipping waste for disposal to the South Carolina, Nevada, and Washington disposal sites was allowed to end in 1992, under a provision of the federal Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) of 1985. That Act is one of two federal laws assigning responsibility for LLRW management and disposal to each of the 50 states.

Another law also affects Massachusetts LLRW generators' ability to ship for disposal. It is a South

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[1] The total number of radioactive materials users licensed or registered in Massachusetts varies from time to time due to the expiration or termination of some licenses and registrations, and the issuance of new ones.

[2] The Utah site, owned and operated by Envirocare of Utah, Inc., has accepted low-activity LLRW since 1991, and recently received a permit to accept certain low-activity mixed waste (i.e., LLRW that also contains, or exhibits the characteristics of, toxic, chemical "hazardous" waste). Because of the license restrictions on the type of LLRW that can be accepted at this facility, Envirocare disposes of such high-volume, low activity bulk waste as contaminated soils and building rubble from decommissioning projects. Envirocare disposed of 7,450 cubic feet of LLRW in 1991, and 60,479 cubic feet of LLRW in 1992 from Massachusetts generators. Because most of this waste volume resulted from various one-time decommissioning projects, such high volume of waste shipments to Envirocare is not expected to remain constant on a yearly basis.

Carolina law, that allows continued access for LLRW generated from outside the Southeast Compact region until June 30, 1994. However, in order to gain access to the Barnwell disposal site, a request for access from each out-of-region state must be approved by the members of the Southeast Compact Commission, which represents the eight member states in the compact. Acceptance also requires the endorsement of the two Compact Commissioners representing the State of South Carolina.

In October, 1992, the Southeast Compact Commission finalized language for contracts between individual states and compact regions that the Commission had determined were eligible to enter into agreements for up to 18 months of continued access to the Barnwell site. The contract and the Compact Commission's "Import Policy" -- referenced in the contract -- stipulate that the Commission will review each state and region's progress towards providing for LLRW disposal. If it determines that such progress is inadequate, the Commission will terminate the contract before the 18-month access period ends in June, 1994. Review periods were conducted in December, 1992, and April and October, 1993.

In addition, the Commission's Import Policy allows it to terminate the contract, if, in the Commission's view, a state or region takes an "overt action" that "substantially impedes" disposal facility siting progress.

The Southeast Compact Commission included in the contract a $220 per cubic foot surcharge on waste accepted at Barnwell. The majority of that fee -- $160 per cubic foot -- has been paid to the State of South Carolina, as required by the new Barnwell access law. The reminder of the surcharge -- $60 per cubic foot -- is being used by the Southeast Compact Commission to finance the development of the Compact's new disposal site in North Carolina (currently scheduled to open in 1996 after Barnwell ceases operations), and to provide funds for any Commission contingencies.

In October, 1992, the Southeast Compact Commission accepted Massachusetts' formal request for extended access to Barnwell, made by the Massachusetts Low-Level Radioactive Waste Management Board on behalf of LLRW generators in the Commonwealth. A contract between the Commission and Massachusetts was transmitted to the Management Board, which on Nov. 9, 1992, voted to execute the agreement. The Management Board supplied the necessary "interim" reports to the Commission in December, 1992, and April and October 27, 1993. However, at the Commission's meeting in October, 1993, eight of the 16 Commission members present voted to terminate the contract with Massachusetts. Because the vote ended in a tie, contract termination did not occur. However, the Commission notified the Management Board on Oct. 27, 1993, that another termination vote would be taken if three actions did not occur in the Commonwealth:

- approval of this LLRW Management Plan in December, 1993;
- approval by the Massachusetts Legislature of a $45 million bond authorization by the end of the 1993 legislative session; and
- a vote on Feb. 16, 1994 (the date set by the Management Board) on the issue of whether or not to site an LLRW disposal facility within the Commonwealth.

The Contract's Impact on LLRW Management

Retaining the use of the Barnwell disposal site postponed a lack of disposal facility capacity for 18 months from Jan. 1, 1993, to June 30, 1994. However, it does not change long-term LLRW management and disposal policy. After June 30, 1994, with the exception of some LLRW that may be sent to the Utah site, all Massachusetts generators will have to store their waste on site until other, more permanent solutions are obtainable.

Since 1989, the Management Board has been urging all radioactive materials licensees in the Commonwealth to prepare on-site storage space for LLRW that they would have shipped for disposal, and to seek U.S. Nuclear Regulatory Commission (NRC) approval of any necessary amendments to their possession-limits licenses. Licensees have been encouraged by the Management Board to increase their already-successful efforts at waste minimization, and to work with the Board, which is charged with developing long-term solutions for LLRW management.

The only short-term option available for nearly all licensees is apparently the use of on-site storage. As is explained in Chapter 12, the licenses issued by the NRC authorize radioactive materials users to store LLRW on site for the duration of their licenses, as long as they do not exceed the overall number of curies of activity their licenses allow them to possess.

However, on-site storage cannot solve the LLRW management problem. The NRC does not encourage storage, and their guidance to generators opposes on-site storage for longer than five years.

This chapter evaluates the availability of in-state and out-of-state facilities for storage, treatment, and disposal, after the disposal site in South Carolina is no longer accessible to Massachusetts LLRW generators. This chapter also projects the volumes and activity (in curies) of LLRW anticipated to be generated in Massachusetts in the future, assesses the need for additional facility capacity in all three management areas, and identifies proposed disposal facility size and capacity specifications.

A finding that there is a need for additional LLRW facility capacity does not automatically require the Management Board to vote to initiate LLRW facility site selection within Massachusetts. A lack of capacity within the Commonwealth could be handled by entering into agreements with other states to grant Massachusetts LLRW generators admission to storage, treatment, or disposal facilities in those states.

All of the plausible options for solving capacity shortages are presented in section 15.8 of this chapter.

15.2 Availability of LLRW Storage

LLRW storage can occur on site or off the site where the waste was generated, but only for a limited period of time. Individual LLRW generators can store their waste on site, or, if their licenses allow, may share storage space with other generators. Storage can also be provided at centralized storage facilities. If such a centralized storage facility were determined by the Management Board to be necessary in Massachusetts, it would be sited, licensed, and operated according to the provisions of Massachusetts General Laws c.111H (Chapter 111H), the Massachusetts Low-Level Radioactive Waste Management Act. If the Management Board determined the need to establish an "interim or emergency" storage facility, Chapter 111H, section 12(b)(10) authorizes the Board to bypass certain site selection and operator selection steps identified in the Act. These steps could be omitted in the case where the Management Board might determine that an emergency storage need exists, and has a location for construction of an interim and emergency storage facility.

In-State Storage Facilities

As was noted in the discussion on storage in Chapter 12, there are no existing licensed "facilities" within Massachusetts, as defined in Chapter 111H, for the centralized storage of LLRW, either for "interim" (up to five years) or "long-term" (greater than five-year) time periods, available to all Massachusetts

generators.[3]

With the exception noted in Chapter 12 of one licensee[4] that provides waste for storage from a small group of "affiliated" licensees, all LLRW storage occurs at the site where the waste was generated, at another site owned by the company or institution, or at out-of-state commercial treatment facilities that provide some short-term storage for their customers.

The Management Board's 1990 Survey of Radioactive Materials Users asked about their on-site storage capacity and their willingness to provide shared storage arrangements for other Massachusetts generators. None of the respondents indicated that they would experience any "substantial" problems in providing for storage at their sites after 1992 when all three sited states' disposal sites were expected to be closed to Commonwealth generators. Only three small-volume LLRW generators anticipated any storage difficulties. These three felt their obstacles could be resolved with some technical assistance from the State. On the question of sharing storage space, LLRW generators cited concerns over their liability, and declined to volunteer to provide shared storage with other Massachusetts generators.

The results of the 1990 survey questions about on-site storage are being verified again by an independent contractor retained by the Management Board. Dames and Moore, Inc. was hired to survey every Massachusetts LLRW generator in 1993, in order to ascertain what preparations have been made by each generator to prepare for on-site storage. The consultant also conducted site visits of the generators' storage areas, to determine, first-hand, what storage arrangements had actually been made.

The results of the Dames and Moore work are scheduled to be released in January or February, 1994. However, based on a review of the data collected, it is expected that on-site storage will continue to be a practical short-term solution for LLRW generators in the Commonwealth.

Out-of-State Storage Facilities

There are no out-of-state commercial storage facilities in operation that are available for Massachusetts LLRW generators. However, a few out-of-state treatment facilities store waste following treatment for eventual shipment to a disposal site. All "brokers" and "processors"[5] were surveyed in early 1992 by the Management Board, to ascertain their capacity to store Massachusetts LLRW at their facilities. Responses indicate the national trend among processors: their limited storage space will be available to their customers only for very short periods of time.

For example, customers from states in the Northwest Compact, who will continue to have access to the Hanford, Washington, disposal site, will be able to have their waste stored at a processor's facility after treatment, and before the waste is shipped to the Washington disposal site. Massachusetts generators will be able to utilize the processor's storage space after treatment and before the waste is shipped back

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[3] A "facility" is a parcel of land, including the structures, equipment, and improvements belonging to the site, which is developed for storage, treatment, or disposal of LLRW generators' waste, in accordance with various siting steps required by Chapter 111H. Because the steps outlined in the Act have not to date been utilized for "facility" development, there are no licensed "facilities" in Massachusetts as defined by Chapter 111H, and the few existing licensees who accept waste for storage or treatment from other generators are grandfathered by a provision in another state law.

[4] Harvard University.

[5] A "broker" is a company that arranges for collection, packaging, shipment, treatment, storage, or disposal of LLRW. A "processor" is a company engaged in the business of treating LLRW.

to the generator in Massachusetts. No processing companies indicated that they had the capacity to store LLRW on site for extended periods of time. It is clear that these companies do not have the capacity to store the entire nation's waste.

Availability of Storage Facilities to Massachusetts Generators

As long as on-site storage is feasible for Massachusetts LLRW generators, there appears to be no lack of storage capacity. Because neither NRC nor Massachusetts Agreement State regulations allow storage to take the place of long-term disposal, storage is merely an interim solution for LLRW management. If the Management Board were to determine that interim centralized storage were necessary to protect health and safety, that interim solution would not take the place of long-term disposal, but would, instead, complement any long-term management decision.

15.3 Availability of LLRW Treatment

Like storage, some treatment activities can occur on site where LLRW is generated if the treatment is consistent with, or has been approved by, the NRC as a license condition. One of the most-used on-site treatment processes is storage for decay, by which LLRW with a relatively short half-life is held for natural radioactive decay in compliance with federal and state regulations. After the LLRW has decayed to background radiation levels, it can be disposed of as essentially non-radioactive trash.[6] Like storage, LLRW treatment can also occur off site in centralized processing facilities.

In-State Treatment Facilities

As noted in Chapter 11, there are no treatment "facilities" operating in Massachusetts that have been established according to the siting provisions of Chapter 111H. With the exception noted in that chapter of the one existing commercial treatment operation within Massachusetts, and the cooperative treatment arrangement of a group of affiliated hospitals and universities,[7] all treatment of LLRW produced in Massachusetts occurs on site or at out-of-state processing companies.

The Commonwealth does not have the authority to force the expansion of the commercial treatment

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[6] In the case of on-site mixed waste treatment, a license would be required from the Massachusetts Department of Environmental Protection (DEP) and also a "Part B" permit from the U.S. Environmental Protection Agency (EPA) (or DEP, once that agency is authorized by EPA to assume regulatory authority over mixed waste). Other details about "mixed waste" LLRW that is contaminated with, or exhibits the characteristics of, hazardous (chemical) waste, can be found in Chapter 8.

[7] Interstate Nuclear Services, Inc., in Springfield, launders radioactively-contaminated clothing for New England's nuclear-powered electric generating plants, as well as for some medical research institutions. It is the only commercial LLRW treatment facility in the Commonwealth. The group of affiliated licensees are Harvard University and the Harvard Medical School affiliated institutions, which use Harvard's Southboro campus to process some of the LLRW these institutions produce. Two buildings at the Campus treat waste through storage for decay. Once the waste has decayed to background radiation levels, most of it is shipped to a commercial incinerator. Some LLRW is incinerated in an on-site incinerator. Both Interstate Nuclear Services and the Harvard Southboro facility were licensed by the NRC to conduct these treatment activities prior to the passage of Chapter 111H. They are not subject to "facility" site identification or other requirements of Chapter 111H.

operation In Springfield or the medical school affiliates' treatment activities In Southboro so that they would have to accept additional LLRW for treatment and thereby serve as "centralized" treatment facilities, even if there was a desire to do so. After Massachusetts becomes an Agreement State, (i.e., assumes authority from the NRC to license various radioactive materials users In the Commonwealth),[8] if either of these treatment activities were to seek license amendments to modify their operations, the Management Board is required by law to review the amendment requests, In order to ensure that they are consistent with this LLRW Management Plan. [St. 1987 c.549] Such a review, however, does not give the Management Board the authority to force the operators of these treatment activities to accept statewide treatment "facility" status.

Out-of-State Treatment Facilities

A number of large commercial operations that process LLRW for Massachusetts generators exist around the country. Table 15-1 lists these companies, their locations, and the type of treatment services they provide.

Availability of Treatment Facilities to Massachusetts Generators

It is not clear whether all the treatment facilities listed in Table 15-1 will be available to accept Massachusetts-generated LLRW, even if they have the capacity to provide such treatment. Questions have been raised about the relationship of brokers and processors to state and federal mandates ever since the LLRWPAA was adopted, which placed requirements on LLRW brokers and processors to track and report waste by generator. Some compact regions do not wish to "lose" the higher volumes of untreated waste that could amount to larger profits for the disposal facility, host state, or site community.

Other compact regions and states fear that treating LLRW by combining more than one generator's waste (and potentially more than one state's waste), and then separating the waste back into "batches" for return to each generator, could result in one LLRW generator's receiving the treated waste product of another generator, and therefore one state potentially becoming responsible for another state's waste. The worry is that the radionuclides that originated in one state may end up as the responsibility of another state.

State Restrictions

One compact region (Central Midwest) and one state (Tennessee) that host some of the treatment facilities listed in Table 15-1 have already established conditional access policies. The language creating the Central Midwest Compact, which includes the States of Illinois and Kentucky, prohibits access to storage and treatment facilities within its region, unless:

- the Central Midwest Compact Commission enters into an agreement to allow access; and
- the local governing body of the jurisdiction hosting the storage or treatment facility gives its consent; and
- the Legislature of the affected host state grants its approval.

Central Midwest Compact law prohibits the establishment of storage and treatment facilities, away from the point of LLRW generation, unless such facilities are determined by the Compact Commission to be "regional" facilities. It had been the intention of the Commission to license all existing commercial storage and treatment operations as regional facilities by the end of 1992, thereby requiring the above conditions

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[8] Please refer to the detailed discussion of the NRC's Agreement State program in Chapter 2.

Table 15-1 Treatment Facilities Used by Massachusetts LLRW Generators	
Company/Location	**Treatment**
ADCO Services, Tinley Park, IL	Volume Reduction; Decontamination; Solidification
Allied Technologies, Richland, WA	Supercompaction
Applied Health Physics, Albany, NY	Supercompaction; Decontamination
Babcock and Wilcox, Park Township, PA	Supercompaction; Decontamination
Chem-Nuclear, Channahon, IL	Supercompaction
Chem-Nuclear, Snelling, SC	Dewatering; Size Reduction of Irradiated Hardware; Decontamination; Supercompaction
DSSI, Kingston, TN	Mixed Waste Incineration; Storage for Decay
GTS Duratek, Columbia, Maryland	Solidification; Liquid Waste Processing
Interstate Nuclear Services, Springfield, MA	Decontamination of Clothing
LN Technologies, Columbia, SC	Solidification; Ion Exchange; Dewatering
NDL Organization, Peeksville, NY	Compaction
NSSI/Recovery Systems, Houston, TX	Decontamination; Volume Reduction; Mixed Waste Processing
Quadrex Corp., Gainesville, FL	Incineration, Liquid Scintillation Vials Processing
RADIAC Research Corp., Brooklyn, NY	Volume Reduction; Decontamination
RAMP Industries, Denver, CO	Compaction; Shredding; Separation; Solidification; Liquid Scintillation Vials Processing
Scientific Ecology Group (SEG), Oak Ridge, TN	Supercompaction; Incineration
Teledyne Isotopes, Westwood, NJ	Volume Reduction; Decontamination
Thomas Gray & Assoc., Orange, CA	Supercompaction; Decontamination
Source: Low-Level Radioactive Waste Management Board Broker and Processors Survey, February, 1992.	

to be met for the continued use of these facilities by Massachusetts generators. Late in 1992, however, the Central Midwest Compact Commission agreed to modify its definition of "regional treatment facility," and its procedure for approval of the conditions listed above. All the conditions would continue to be required, but the proposed Compact law amendment would allow the Central Midwest Compact Commission to enter into agreements with other states (on behalf of their LLRW generators), first, and then later receive the necessary approval from the State Legislature. These procedural changes were adopted by the Illinois and Kentucky Legislatures.

The access policy adopted in 1989 in the State of Tennessee restricts the actions of its processors regarding out-of-state waste. Worried about the consequences to Tennessee if LLRW producers from some states lost access to the disposal sites in South Carolina, Nevada, and Washington, the Tennessee Department of Health and Environment adopted regulations allowing processors to treat LLRW from generators denied disposal access, as long as certain approvals were received. They include certifications of willingness to accept the waste back in the generating state from:

- the Governor of the generator's state;
- the director of the state radiation control program in the generator's state, and
- the representative to a compact commission in the generator's state, if applicable.

Tennessee established these rules for its own protection because of the substantial amount of LLRW processing that occurs in that state. Two processing firms -- Scientific Ecology Group (SEG) and Quadrex -- operate in Tennessee and are the nation's leading volume processors. Tennessee wanted to ensure that waste entering its state for treatment would be sent back to the state of origin, if access to the disposal sites was denied.

The Management Board's efforts to ensure that LLRW generators from Massachusetts would continue to have access to storage and treatment facilities in the Central Midwest Compact states led to the decision by a nationwide organization of state LLRW management officials to uncomplicate access to such facilities. The national LLW Forum, which is comprised of all the states involved in providing LLRW management and disposal (including Massachusetts), finalized an "Interregional Agreement" to offer assurances to the states hosting storage and treatment companies that they would not be burdened with the responsibility for disposing of waste generated outside their borders. The agreement was also designed to avoid the need for separate, state-by-state arrangements.

Although this interregional agreement is not a legally binding contract, its intent is to discourage actions by individual states or compact regions that could hinder LLRW treatment activities nationwide. States such as Massachusetts, and compact regions such as the Central Midwest, could still impose additional conditions, if required by their laws or policies.

Availability of Treatment Facilities to Massachusetts Generators

As long as treatment is available to Massachusetts LLRW generators on site and at out-of-state processing firms, there is no capacity shortfall for LLRW treatment. However, the capacity and availability of out-of-state treatment facilities will be continuously monitored to ensure their availability to Massachusetts LLRW generators. If signals indicate that these processing businesses will be unable to treat Massachusetts-produced LLRW, a reassessment of treatment needs will be necessary.

In the case of mixed waste, treatment does not exist nationwide for all types of mixed waste, due to certain regulatory requirements, discussed in Chapter 8, that have discouraged processors from providing the capability for mixed waste treatment. However, new treatment companies are beginning to be permitted, and a growing percentage of mixed waste is able to receive treatment. In fact, a study completed by NRC and EPA in December, 1992, concluded that ample treatment capacity exists for all but approximately 13% of the mixed waste generated nationally.[9]

Because of the rise in mixed waste treatment capacity, and due to the small percentage of mixed waste generated, it appears to be impractical for Massachusetts to assume a lack of availability of mixed waste treatment. However, the ability of out-of-state processing companies to treat mixed waste will be monitored, and information about new mixed waste treatment companies will be routinely made available to Massachusetts mixed waste generators.

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[9] The study used national mixed waste generation data for the year 1990. Knowing the correct percentages of companies and institutions nationwide that comprise five major radioactive materials users categories (i.e., academic, commercial, medical, nuclear utility, and non-federal government), the 1990 data was weighted to develop a statistically accurate "national profile" of mixed waste generation.

In addition, as noted in the recommendations in Chapter 8, DEP needs to change its regulations to allow mixed waste containing short half-life material to be eligible for storage for decay, so that this material can be stored on site to eliminate the radioactive contaminants, and then be disposed of as hazardous waste, not mixed waste.

15.4 Availability of LLRW Disposal

A few on-site disposal options are authorized by the NRC in its regulations in Title 10, Part 20 of the Code of Federal Regulations [10 CFR Part 20], and are summarized below:

On-Site Burial. NRC regulations [10 CFR 20.2002] allow licensees to bury small volumes of low radioactivity LLRW on site. Each application is to be considered on a case-by-case basis. Of the 41 applications submitted to NRC from across the country (three applications from Massachusetts), only 23 have ever been approved, including one in the Commonwealth. After the NRC promulgated its LLRW disposal licensing regulations in 1983, it began discouraging radioactive materials users from on-site burial. The one authorized to bury on site in Massachusetts discontinued this action in the mid-1980s.

Sewer System Discharge. NRC regulations [10 CFR 20.2003] prohibit the discharge of radioactive material into sanitary sewer systems except for very small quantities which are expected to be diluted by the volume of sewage and water flowing through the system. The rule prohibits any licensee from using the sewer system to discharge more than a combined total of one curie per year of all radioactive materials, with the exception of Carbon-14 and Hydrogen-3. Up to one curie per year of Carbon-14, and as much as five curies per year of Hydrogen-3, may be released into the sanitary sewer system under set concentrations at the point of discharge.

Exempt Quantities. Minute quantities of certain radionuclides do not have to be disposed of in licensed LLRW disposal facilities under NRC regulations. [10 CFR 20.2005] The rule allows: (1) 0.05 microcuries or less of Hydrogen-3 or Carbon-14 in liquid scintillation fluids (LLRW produced primarily by the medical research industry), and (2) 0.05 microcuries or less of the same two radionuclides per gram of animal tissue "averaged over the weight of the entire animal," to be disposed of as non-radioactive trash.

Release in Effluents (Air or Water). In addition, NRC allows radionuclides in radioactive materials or LLRW to be released in effluents (air or water) as long as the release remains within the radiation dose limits allowed by NRC regulations (described in Chapter 3). Appendix B to 10 CFR 20.1001 through 20.2401 includes tables showing allowable "annual limits on intake" (ALIs) and derived air concentrations (DACs), and the chemical form of each radionuclide. The concentration values given in Table 2 of Appendix B (effluents: air or water) are equivalent to the radionuclide concentrations which, if inhaled or ingested continuously over the course of a year, would produce a total effective dose equivalent of 50 millirem.

In-State Disposal Facilities

No disposal "facilities" have been sited, licensed, or developed in the Commonwealth in accordance with the requirements in Chapter 111H.

Out-of-State Disposal Facilities

Three state-controlled commercial disposal facilities and one privately owned and operated disposal site accepted Massachusetts waste until Dec. 31, 1992. As noted earlier in this chapter, the Nevada site closed, effective on Dec. 31, 1992. The Washington site continues to operate for the Northwest and Rocky

Mountain Compact regions, comprising 11 western states. The South Carolina site is scheduled to remain open to Massachusetts through June, 1994. However, it may remain open for only a portion of that period, depending upon whether the Southeast Compact Commission determines that Massachusetts has made "adequate progress toward providing for disposal of their own LLRW."[10]

Also providing out-of-state disposal capacity is the Envirocare disposal site in Clive, Utah. Since 1988, this company has accepted for disposal at its desert shallow land burial site Naturally Occurring Radioactive Material (NORM), Naturally-occurring and Accelerator-produced Radioactive Material (NARM), certain mixed waste,[11] and large-volume, non-reactor, bulk waste from government and commercial decommissioning and clean-up projects, which is only slightly contaminated with LLRW.

Because of the limitations placed on Envirocare's license by the State of Utah, this commercial disposal site cannot accept most of the LLRW produced in the nation, and therefore cannot replace the disposal capabilities of the three sites in South Carolina, Nevada, and Washington.

New Disposal Facilities

Eleven state and regional disposal facilities intended to serve 45 states are in some stages of planning, development or operation. Ten will be regional facilities;[12] one (New York) is planned in this "go-it-alone" state which is not a member of a regional compact. New York may ultimately regionalize with other non-compact states to form a new region, or one or more regions may combine, thereby changing the total number of new facilities that may be built nationwide.

The new and existing disposal facilities and their compact regions/states are shown on Figure 15-A, and are summarized below.

Appalachian Compact. Pennsylvania is the host state for this compact region, which includes the States of Delaware, Maryland, Pennsylvania, and West Virginia. The facility will be located on approximately 500 acres of land, with the disposal area occupying about 50 acres. The facility is designed to accept up to 235,000 cubic feet each year for 30 years.

Pennsylvania selected Chem-Nuclear Systems, Inc. to serve as site developer and operator. Chem-Nuclear will identify three potentially suitable sites that must be certified by the state's Environmental Quality Board as meeting the State's siting criteria regulations, before detailed site characterization can begin.

The siting process involves three stages, namely (1) statewide screening; (2) regional screening; and (3) local disqualifying criteria. Stage two was completed in 1993; stage three will lead to three possible sites for detailed characterization in the late summer of 1994. In late 1994 or early 1995, Chem-Nuclear will submit to the Environmental Quality Board data which will lead to the selection of three finalist sites. The facility is expected to open in mid-1999.

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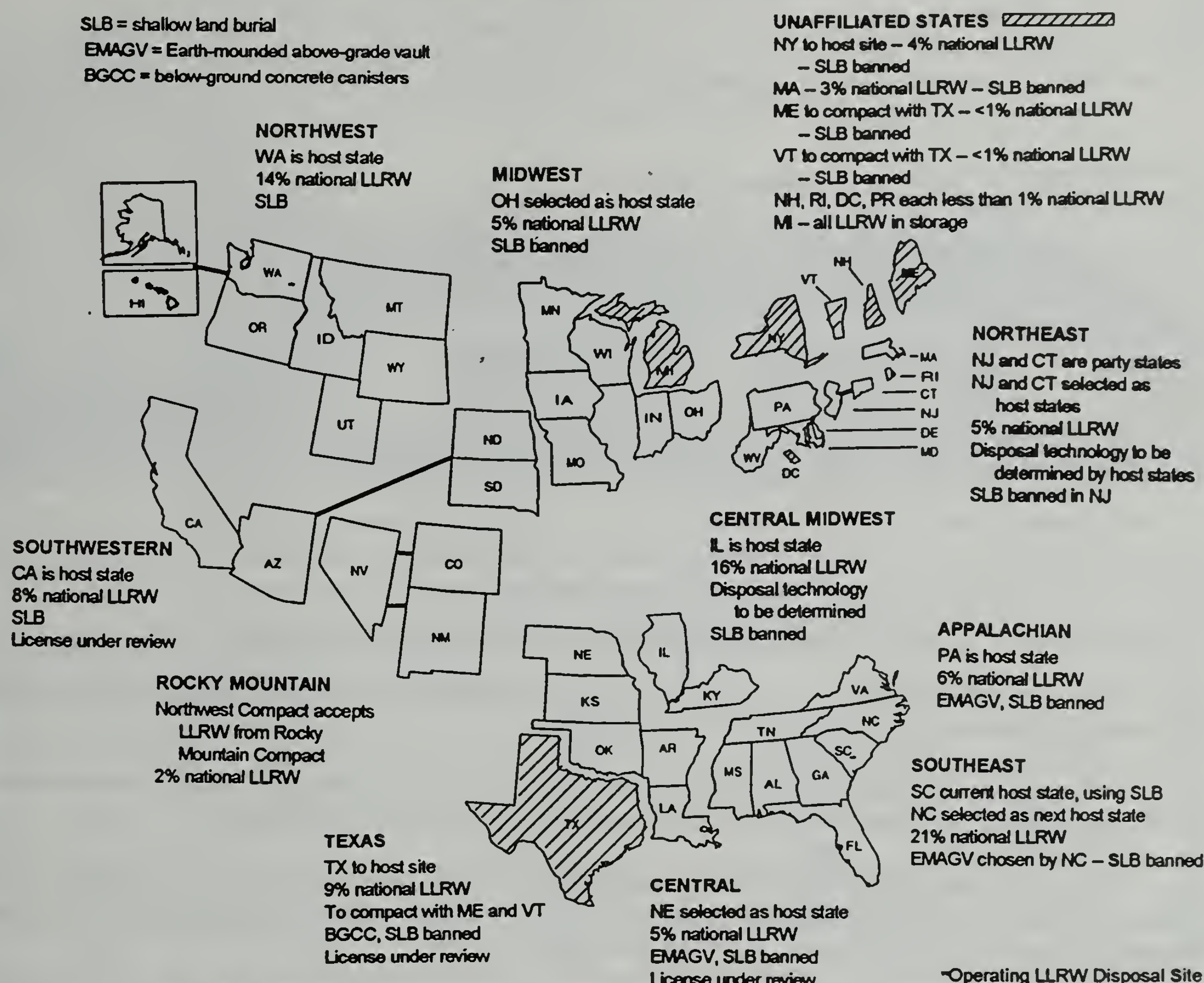
[10] Quote from a letter to the Management Board from the office of South Carolina Governor Carroll A. Campbell, Jr., July 1, 1992.

[11] Ever since Envirocare received its "Part B" permit required under the federal Resource, Conservation and Recovery Act (RCRA), on Nov. 30, 1990, the company has been able to accept certain low activity mixed wastes for disposal. It is the only licensed mixed waste disposal site in the country.

[12] Two of the "regional" disposal facilities will accommodate only one region, due to the fact that Connecticut and New Jersey (the Northeast Compact region) are each planning an LLRW disposal site.

Figure 15-A
Current Configuration of Compact Regions and Unaligned States



Source: U.S. Nuclear Regulatory Commission

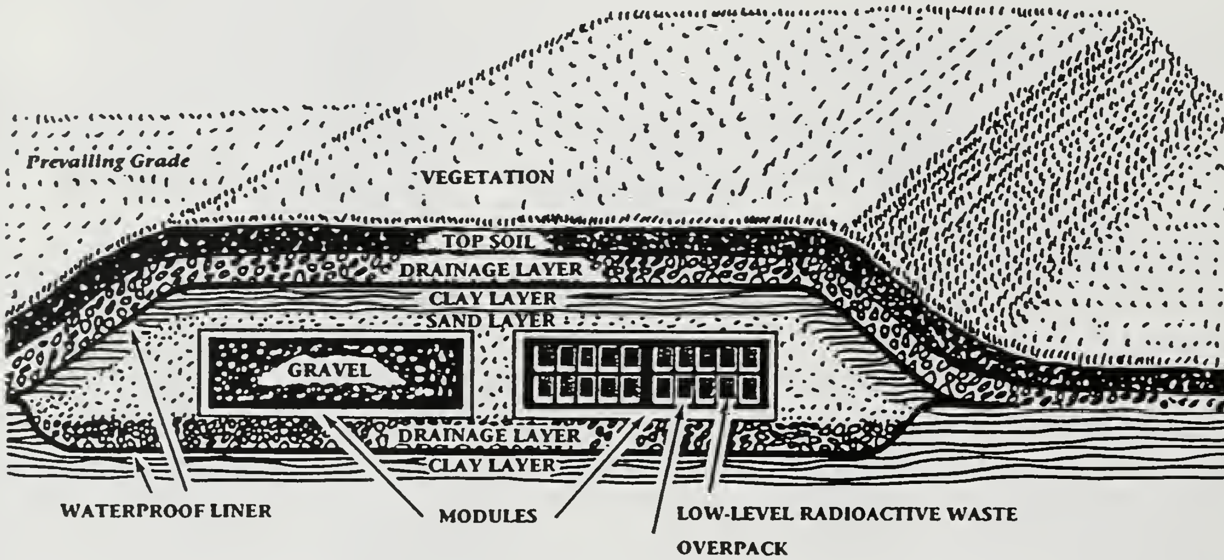
Pennsylvania law prohibits shallow land burial and, like Massachusetts law, requires the facility to allow waste monitoring and recovery. The Pennsylvania statute also requires the disposal facility to be an above-grade engineered facility.

Chem-Nuclear's "triple safe" design is expected to meet Pennsylvania's stringent design regulations for an engineered facility. Modified from a disposal facility operating in l'Aube, France, the Pennsylvania facility will employ a multiple-barrier system which Chem-Nuclear says is capable of isolating waste longer than 500 years. An illustration of the Chem-Nuclear design appears in Figure 15-B.

LLRW entering the site would be loaded into thick-walled concrete overpacks and encapsulated with a fluid concrete grout. The overpacks would then be packed into concrete modules, each capable of holding about one year's worth of LLRW. Finally, the modules would be covered with an engineered cover, which would be layered to divert rainwater away from the disposal units.

In addition, all waste-handling operations are expected to be carried out using a moveable building

Figure 15-B
Appalachian Compact Disposal Facility Design



Source: Chem-Nuclear Systems, Inc. "A Citizen's Guide To Public Involvement." Harrisburg, PA, 1991.

so that a roof is overhead to prevent rain from contacting the waste. Also, the facility will include equipment to monitor any releases of radioactivity into the air and soil.

Pennsylvania does not plan to include mixed waste in its initial license application, but is designing its facility to dispose of mixed wastes and NARM wastes at a later date, if necessary.

Wastes accepted at the facility will be classified according to the NRC disposal classification system, Classes A, B, and C. Pennsylvania has applied to the NRC for "full" Agreement State status[13] to regulate all aspects of its disposal facility, and its LLRW generators.

Availability to Massachusetts Generators

Pennsylvania law prohibits the facility from accepting waste generated outside the Appalachian Compact region, except in emergencies.[14] The emergency condition requires other compacts to agree to accept a comparable amount of Appalachian Compact waste, once their emergency has abated.

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[13] The Agreement State program allows a state to apply to NRC for approval to assume regulatory activities over the licensing of radioactive materials use. "Full" Agreement State status gives a state the authority to license and regulate most users of radioactive materials (except nuclear-powered utility plants, research reactors, and federal installations) and waste disposal facilities. "Limited" Agreement State status assigns the state the authority only to regulate disposal facilities.

[14] An emergency disposal situation is defined in Compact law as a temporary shutdown of the regional facility which is anticipated to extend beyond the storage capacity of the generator, resulting in additional storage causing a public health and safety or environmental threat.

The Compact Commission may grant three-month emergency permits to each generator seeking such access, but lengthier permits require approval by the Pennsylvania General Assembly or the Governor.

The Appalachian Compact enabling law prohibits Massachusetts from becoming a member. If the Compact were amended so that Massachusetts could join, another provision of the Compact law would likely trigger disposal facility siting within Massachusetts. That condition requires that any party state which, for three consecutive years, generates more than 25% of the activity or volume produced in Pennsylvania, must immediately initiate development of a regional disposal facility, to be operational in five years.

Looking at the years 1990, 1991, and 1992, as an example, Massachusetts would be required to begin in-state siting activities to develop a regional facility as host state for Massachusetts, Pennsylvania, West Virginia, Maryland, and Delaware. Table 15-2 shows the volumes, activity, and mean averages for LLRW generated in Pennsylvania and Massachusetts during this three-year period. One-quarter of Pennsylvania's yearly average volume is 34,935 cubic feet and one-quarter of its average activity is 45,241 curies. Massachusetts exceeds 25% of Pennsylvania's volume for all three years.

Massachusetts' total volumes are steadily declining, and are expected to level off at approximately 20,000 to 25,000 cubic feet per year by 1995. However, the total number of curies expected to be generated in the waste are projected to continue to rise. Under this circumstance, Massachusetts would likely continue to exceed the 25% trigger.

Table 15-2
Comparison of Waste Generation in Pennsylvania and Massachusetts

Year	Pennsylvania		Massachusetts	
	Volume (cubic feet)	Activity (curies)	Volume (cubic feet)	Activity (curies)
1990	101,604	47,306	40,613	86,641
1991	224,561	354,340	42,686	32,531
1992	93,050	141,248	119,004	76,363
Average	139,738	180,965	67,434	65,178

Sources: 1992, State-by-State Assessment of Low-Level Radioactive Wastes Received at Commercial Disposal Sites, DOE/LLW-181, September, 1993; and 1990, 1991, and 1992 Massachusetts Low-Level Radioactive Waste Survey Reports, November, 1991, November, 1992, and October, 1993.

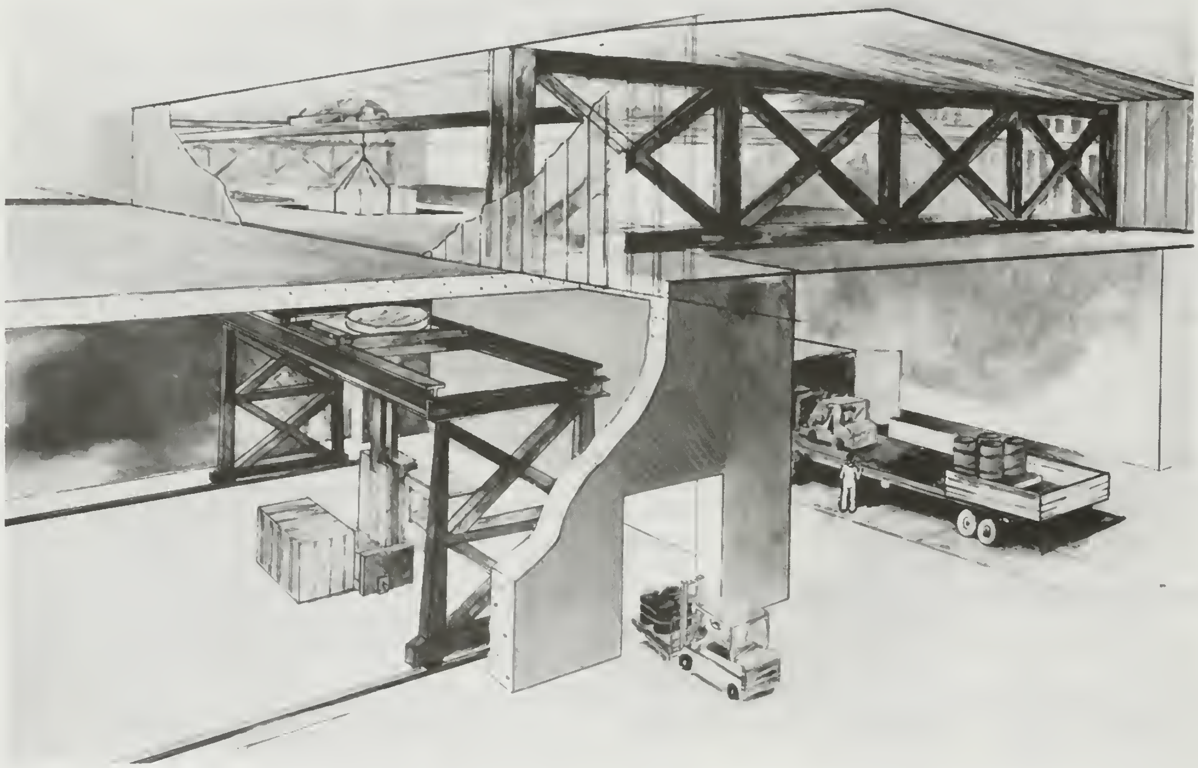
Central Interstate Compact. Nebraska was chosen the host state for the Central Interstate Compact, which includes the states of Arkansas, Kansas, Louisiana, Nebraska, and Oklahoma. US Ecology, Inc. was selected by the compact as the site developer and site operator. Bechtel National, Inc. is US Ecology's prime consultant.

A year-long site selection process ended in January, 1989, with the identification of three final sites. The characterization of those sites was completed in December, 1989. That same month, US Ecology selected one of the three finalists, located in Boyd County near Butte, Nebraska.

The site near Butte is 320 acres. Nebraska law prohibits shallow land burial, and requires the facility to have an engineered barrier constructed between the waste and the site's natural characteristics. Class C wastes must be stored or disposed of separately from other waste classes in containers that can be easily monitored and retrieved.

US Ecology's facility design incorporates above-grade concrete reinforced vaults constructed inside a concrete warehouse-type building. Figure 15-C illustrates the multi-engineered barrier technology designed for this facility, which is scheduled to begin operation by September, 1998.

Figure 15-C
Nebraska LLRW Disposal Facility for the Central Compact
Artist's Conception of a Class A Waste Cell



Source: U.S. Ecology, Lincoln, NE, 1993.

The license application to build, operate, and close the facility was submitted to Nebraska state regulators in July, 1990. After a determination by the State in December, 1991, that the application was complete and ready for technical review, several rounds of technical questions were forwarded to US Ecology. This technical review is ongoing.

The Nebraska siting process was stalled early in 1993, by two actions. In January, the Nebraska Departments of Environmental Quality and Health announced their "intent to deny" the license application, based on their interpretation of difficulties from wetlands located in the site's buffer zone. US Ecology proposed a site reconfiguration to eliminate the wetlands from consideration. In October, 1993, state regulators withdrew their "intent to deny" status, and proceeded with their review of the license application.

Also in January, 1993, Nebraska's governor caused a federal lawsuit to be filed, alleging that the Central Compact Commission had failed to gain "community consent," a requirement of the Nebraska siting law. Both the Compact Commission and US Ecology argued that all applicable laws have been satisfied,

including community consent. This lawsuit was decided in favor of the Compact Commission; however, the State has an appeal pending. In addition, a second lawsuit on community consent was filed, and is also pending.

As a result of these actions, in April, 1993 (effective July 1, 1993), the Southeast Compact Commission terminated the Central Compact's access to the Barnwell disposal site. In October, after Nebraska and the Central Compact Commission submitted a plan demonstrating that their siting efforts were moving forward (since the Commission motion for summary judgment was granted in connection with the first community consent case), the Southeast Compact Commission reinstated the Central Compact's access contract.

The Central Compact's license application does not include mixed waste disposal. Because the region produces so little mixed waste (approximately 250 cubic feet per year), the economics of building a separate vault for mixed waste are such that the Compact region is pursuing alternatives for mixed waste disposal. The preferred alternative involves acceptance of this waste at a U.S. Department of Energy (DOE) research installation.

As a "full" Agreement State, Nebraska will regulate both the disposal facility and its generators.

Availability to Massachusetts Generators

The language of the Central Interstate Compact law approved by the compact states and by Congress expressly prohibits any waste from outside the region into its regional compact facility, unless the Compact Commission approves waste importation, including the affirmative vote of the Nebraska commission member. Current Central Compact officials have made their intentions clear that they do not support waste importation. It is therefore highly unlikely that the Nebraska site will become available to Massachusetts generators in the foreseeable future.

Central Midwest. The Central Midwest Compact is a two-state compact comprised of Illinois and Kentucky. Illinois, which produces more than 90% of the region's waste, is the host state.

Illinois has begun siting anew, following the disapproval of its first siting effort. Through a process that included soliciting volunteers and statewide screening, the director of the Illinois Department of Nuclear Safety (IDNS) selected two sites for site characterization and environmental study from a larger group of alternatives. In April, 1990, one of the two sites was dropped from consideration, leaving only one potential site area presently under review. That site was near the city of Martinsville in Clark County, Illinois.

In January, 1991, the city council in Martinsville approved a resolution in favor of the Martinsville site. This action followed an advisory referendum in Clark County, in which a majority of voters in Martinsville (56%) endorsed the disposal facility, although it was opposed two-to-one on a county-wide basis. In June, 1992, the Martinsville City Council unanimously approved a resolution endorsing a community benefits agreement with IDNS, and reaffirming the city's support "without reservation or condition."

Chem-Nuclear Systems, Inc., the site developer, submitted a license application in May, 1991, to build an engineered facility incorporating overpacks in above-grade vaults. According to Chem-Nuclear sources, the Illinois design for the Martinsville site was "essentially the same" as the one developed for the Pennsylvania and North Carolina sites.

Packages of waste arriving at the facility were to be repackaged, and placed into concrete overpacks, which could each hold from 200 to 400 cubic feet of waste. After the overpacks were filled and sealed with grout, they would be moved to an above-ground concrete waste cell, arranged, and stacked. Sand or gravel would fill in the voids between the overpacks.

Each cell was designed to hold about two to three months' worth of waste. A group of cells was to contain a central monitoring system, with individual connections to each cell, to enable the facility operator to detect the presence of moisture promptly, and to pinpoint its sources.

Each group of cells, called an "engineered vault" by Chem-Nuclear, would be covered with a 10-foot earthen cap to protect further against water or moisture intruding into the cells. The cap would include:

- special coating applied directly to the surface of each cell;
- a layer of structural fill;
- a clay moisture barrier;
- a synthetic, waterproof membrane;
- a drainage layer to direct rain and snow away from the cells; and
- a layer of topsoil planted with vegetation.

Class C waste was to be disposed of in a retrievable fashion. Disposal of mixed waste is prohibited by Illinois law. Illinois would use the NRC's disposal classification system for facility waste acceptance criteria. In addition, it plans to accept Radium-226 classified in the same manner as transuranic materials that have greater than a five-year half-life.

The facility was expected to be operational by mid- to late 1994. However, on Oct. 9, 1992, the Illinois Low-Level Radioactive Waste Disposal Facility Siting Commission voted unanimously to reject the Martinsville site. The siting commission -- a three-member panel created in 1990 and charged with evaluating the safety and suitability of the proposed site -- rejected the Martinsville site following 12 hours of public deliberations, based on testimony received during 71 days of hearings before the Commission. The Commission indicated that its decision to reject the site was based on failure to meet the siting and design criteria.

Illinois Governor Jim Edgar accepted the Commission's recommendation, and ordered IDNS to cease all efforts to use the Martinsville site. The following March, a new siting process became law, with amendments to enhance public participation added to it in May, 1993. The new process creates a Low-Level Radioactive Waste Task Group, comprised of the directors of three state agencies and six individuals appointed by the Governor who have expertise in hydrology, hydrogeology, local government, and other environmental fields.

The Task Group is responsible for developing siting criteria. The Illinois State Geological Survey and State Water Survey are charged with screening the State and evaluating any volunteered sites in order to identify at least 10 areas of a minimum 640 acres each that seem to meet the siting criteria. A siting contractor will then evaluate the identified areas, and select three potential sites for further study. The Task Group must approve of the three candidate sites for preliminary characterization. Finally, the contractor will select one site for detailed site characterization.

Illinois predicts that its new facility will be operational by June, 2000.

Availability to Massachusetts Generators

The Central Midwest Compact Commission has banned acceptance of LLRW from outside its region for disposal. In addition, current Central Midwest Compact law makes Massachusetts ineligible to join the

compact, and the Commission does not recommend amending the compact to expand the number of member states.

Also, Illinois Governor Edgar has been outspoken about refusing to accept waste for disposal from states outside his compact region.

Midwest. The Midwest Interstate Compact Region is comprised of six states: Indiana, Iowa, Minnesota, Missouri, Ohio, and Wisconsin. Prior to its expulsion in July, 1991, Michigan was also a member of the compact and was designated the host state as the largest LLRW generator in the region. Ohio is the new host state for the Compact region, and must first adopt an LLRW management and disposal law before it can proceed with site identification activities. Ohio estimates that its legal framework will be approved in 1994.

Because Michigan had been involved in site selection activities prior to July, 1991, this section contains a brief summary of Michigan's activities before its expulsion from the Compact.

The Michigan Low-Level Radioactive Waste Authority initiated a statewide site screening program to identify a 1,200 acre site by the fall of 1991. In 1989, about 80 areas in the state that contained possible suitable sites were identified, and were further screened to produce three candidate areas. However, by May, 1990, all three candidate areas were eliminated from further consideration.

In November, 1990, Michigan generators were denied access to use the disposal sites in South Carolina, Nevada, and Washington. The Midwest Compact Commission ousted Michigan from the Compact in July, 1991. Both actions followed a series of events that led the three sited states and the Midwest Compact Commission to question Michigan's intent ever to site a disposal facility.

These events included numerous public statements by Michigan's current and past governors against siting within the State, resolutions adopted by the Michigan Legislature expressing opposition to the federal LLRW Amendments Act, the suspension of the Michigan siting process, the refusal to amend its siting criteria to enable a site to be identified, and arguments with the Compact Commission over the use of Commission funds.

Availability to Massachusetts Generators

The language of the Midwest Compact law authorizes the Compact Commission to enter into agreements with individuals, states or compact regions for the right to use Midwest Compact regional facilities. Like the provision contained in the Central Compact, such an agreement requires an affirmative vote of a majority of the Commission, including the concurring vote of the representative of the host state in which any regional facility is located. Ohio officials have indicated that no support exists, either in their state, or among Commission members representing other states in the compact, to allow out-of-region access for disposal.

Michigan's failure to identify a site for the Midwest Compact states has delayed the compact siting process. Ohio estimates that a disposal facility could be sited, licensed, developed, and operational within 7.5 years after its enabling legislation is adopted. If that legislation is enacted in 1994, and the current schedule is maintained, the Midwest facility would begin accepting waste in mid-2001. This schedule may affect Massachusetts' ability to negotiate a contract with Ohio, which, like other states, may be unwilling to accept waste from outside its compact region prior to the operation of its facility, and before support is gained from its citizenry.

Northeast Compact. The Northeast Interstate Compact originally had four member states. However, Delaware and Maryland joined the Appalachian Compact, and left Connecticut and New Jersey as the two

states in the Northeast compact. Both are developing disposal facilities for the LLRW generated in their respective states.

Like Illinois, Connecticut halted its earlier siting process, and is proceeding with a new "volunteer" approach. Regarding the old siting process, Battelle Memorial Institute was hired in September, 1990, by the Connecticut Hazardous Waste Management Service to conduct a broad, statewide screening to select three potential sites. Volunteer sites were encouraged, and the entire state was evaluated for sites using environmental exclusionary criteria.

Connecticut law, like that of Massachusetts, prohibits the contractor that is hired to identify sites from also serving as the developer and operator of the disposal facility, in order to ensure that a developer does not select a site for reasons of expediency. In February, 1991, Chem-Nuclear Systems, Inc. was selected as the facility developer/operator.

Three final 160-250 acre sites were announced by the Waste Management Service in June, 1991, to undergo detailed characterization. An immediate public uproar ensued. Because of questions raised by the Service's separate review of Battelle's technical siting work, the siting process was suspended while Waste Management Service hired an independent contractor to evaluate the siting effort.

In May, 1992, the Connecticut Legislature passed a law directing the Waste Management Service to terminate its siting effort and to prepare a plan for a new siting effort. The new plan received legislative approval in 1993. The Legislature also modified the State's siting criteria by adding an earlier evaluation of "sensitive" facilities near any site, such as schools, hospitals, nursing homes, etc.

The Connecticut Legislature approved the new "volunteer" siting approach in April, 1993. This program, which is entirely voluntary in nature, allows the State to consider only sites that have been approved by the voters in town-wide referenda. Grants will be offered by the Waste Management Service to municipalities and regional governments interested in developing and participating in public education programs. At the same time, the Waste Management Service will invite towns to participate in volunteering sites. Participation by a community will include identifying a site, negotiating a facility development agreement, and holding a referendum on the site and the agreement. Until approval occurs In a referendum, the municipality may withdraw at any time, and for any reason.

A number of incentives are contained in Connecticut's volunteer approach. The financial inducements are shown in Table 15-3. Another incentive in Connecticut's program includes a provision that any town that participates in the volunteer program and holds a referendum, regardless of the outcome, will be exempt from any later statewide screening process that may be necessary if a volunteer site is not approved. In addition, the Waste Management Service will pay all of the municipality's costs to participate in the volunteer process.

While the number of towns that may join the volunteer process and cause these expenditures to be incurred can only be estimated at this time, Connecticut speculated In November, 1993, that its estimatedsiting and initial construction costs would be approximately $100 milllon dollars. All these costs would be paid through assessments on LLRW generators.

Connecticut LLRW management officials project that a disposal facility will be operational by December, 1999.

No prohibition on using shallow-land burial as a disposal technology exists in Connecticut law. However, the Waste Management Service eliminated shallow land burial from consideration as a disposal method, and Intends to develop a facility similar in design to the ones planned for Illinois and Pennsylvanla.

Table 15-3 Compensation and Incentives in Connecticut's Volunteer Siting Program			
Action Required by Town to be Eligible for Compensation	$ Received by Single Town	$ Received by Regional Group	
		Site Town	Non-Site Town
Notify Waste Management Service that town will take part	$250,000	$300,000	$200,000*
First to notify Waste Management Service	$100,000	$150,000	$ 50,000*
Six months of siting and "good faith" negotiation	$250,000	$300,000	$200,000*
Voters approve site, agreement in referendum	$1,000,000	$1,500,000	$500,000*
Initial compensation (negotiations start at)	$2,000,000	$2,000,000	Negotiated
Annual payments (negotiations start at)	$1,000,000	$1,000,000	Negotiated
Annual assessment on facility gross receipts	$500,000	$500,000	Negotiated

* The figures shown with asterisks are the payments that would be made to each non-site town if there are 10 or fewer non-site towns in the regional group. The maximum payment to the non-site towns is 10 times the figure given. A group of more than 10 non-site towns would divide the maximum payment.

Source: Connecticut Hazardous Waste Management Service. 1993 Low-Level Radioactive Waste Management Plan, Vol. 2: Volunteer Approach to Siting a Low-Level Radioactive Waste Disposal Facility in Connecticut. Hartford, CT, January, 1993.

Neither Connecticut nor New Jersey are Agreement States, and their facilities will be licensed by the NRC. Both facilities will accept wastes classified as A, B and C according to the NRC disposal classification system, as well as mixed waste.

New Jersey Siting Progress

Siting criteria were adopted by the New Jersey Low-Level Radioactive Waste Disposal Facility Siting Board in April, 1990, and a disposal technology selection methodology was adopted in May, 1990. In 1991, the Board selected Ebasco Services, Inc. as the contractor for site identification and characterization. Several sites were to be pre-characterized prior to the selection of one or more sites for detailed site characterization.

Because of siting difficulties experienced in Connecticut and other states, the New Jersey Siting Board voted in 1992 to develop a voluntary siting process. Board members were appointed to an advisory committee to make recommendations to the Governor.

The site identification work by Ebasco was cancelled. The advisory committee recommended to the Siting Board a voluntary siting process very similar to Connecticut's process, and such a program was being established late in 1993. New Jersey officials estimate their disposal facility will be operational by October, 1998.

New Jersey state law prohibits shallow land burial, but the type of engineered facility technology has not yet been determined.

Availability to Massachusetts Generators

No legal impediments in the Northeast Compact law prohibit Massachusetts from joining the

compact as a party state, or contracting to send its waste to a compact facility. However, Connecticut law prohibits Connecticut's Compact Commission member from supporting any request for the importation of out-of-region waste, unless the chief elected official of the Connecticut site community gives written approval. In addition, officials representing the Commission and both party states have expressed opposition to accepting any out-of-region waste for disposal. They have continued a dialogue with Massachusetts Management Board officials, however, out of an interest to send their waste to a Massachusetts disposal facility.

Northwest Compact. Eight states comprise the Northwest Compact: Alaska, Hawaii, Idaho, Montana, Oregon, Utah, Washington, and Wyoming. Washington, the host of one of the three regional commercial disposal facilities which accepted LLRW from around the country until Dec. 31, 1992, continues to serve as the host state for the Northwest Compact region, utilizing space at its Hanford site. The site, a 100-acre shallow-land burial operation, is expected to continue accepting LLRW for disposal until the State's site lease with DOE expires in the year 2063.

The following site design description was provided by Washington State to the Host State Technical Coordinating Committee for its January, 1991, "Progress Report:"

> "Waste is predominantly disposed of by conventional shallow land burial methods in disposal trenches. Of the existing 18 trenches at the site, there is a single designated "chemical trench" of unknown dimensions, while trenches one through six range from approximately 295 to 410 feet long, 59 to 141 feet wide, and 23 to 33 feet deep. Current trench maximum dimensions allowed in the operating license are 1,000 feet long, 150 feet wide, and 45 feet deep. All trenches are unlined. Drums of Class A LLRW received (approximately 98% by volume) are disposed of randomly in the trenches, while Classes B and C LLRW (approximately 2% by volume) are emplaced in segregated trench areas. Drums of Class A waste containing either solidified oils or chelates[15] in quantities exceeding 0.1% are also segregated. Variations to shallow land burial methods in the facility design have included the use of caissons for disposal of high exposure rate LLRW, and five underground evaporator tanks, comprising the resin tank farm, for liquid LLRW. The five underground evaporator tanks have been inoperative and closed for a number of years."

Additional information about the commercial LLRW site at Hanford and the other commercial disposal sites can be found in Appendix 1A of Chapter 1.

The Hanford site is operated by US Ecology, Inc. Mixed waste is not currently accepted at the site. The Northwest Compact is considering various options for the disposal of its mixed waste, including further treatment and waste minimization, and contracting with another state or region to take this waste.

The Northwest Compact Committee negotiated an agreement with the Rocky Mountain Low-Level Radioactive Waste Compact Board to accept waste produced by the Rocky Mountain Compact states (Colorado, Nevada, and New Mexico). The contract allows disposal from those states only, to begin on Jan. 1, 1993. The Rocky Mountain Compact Board has agreed to pay $2.5 million to use the Washington disposal site, and may send up to 6,000 cubic feet of LLRW to Hanford each year.

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[15] A "chelating agent" means certain organic compounds which are capable of bonding with metals to improve the thermodynamic stability of the metals in solution, and change the behavior of the metal ions. Examples of chelates for LLRW disposal include amine polycarboxylic acids (e.g., EDTA, DTPA), hydroxy-carboxylic acids, and polycarboxylic acids (e.g., citric acid, carbolic acid, and gluconic acid).

Availability to Massachusetts Generators

The Northwest Compact enabling law prohibits Massachusetts from joining the compact as a member state, or contracting with the compact for waste disposal. A compact provision prohibits the Compact Committee from approving any arrangements to accept out-of-region waste without the affirmative vote of the committee member representing the host state. In addition, host state Washington law directs the Washington committee member to approve access only for states in the Rocky Mountain Compact or for states that (1) generate less than 1,000 cubic feet of waste annually, and (2) are contiguous with a member states of the Northwest Compact. On Dec. 10, 1992, the Compact reinforced its prohibition on access by adopting a resolution stating that it will accept only LLRW that was generated in the Northwest or Rocky Mountain compact regions, or that "is the subject of a specific agreement previously or hereafter approved by the Northwest Compact Committee."

The Management Board received a written communication from the Northwest Compact in December, 1989, stating Washington's intention to accept waste only from states within its region beginning Jan. 1, 1993. Numerous verbal communications with Washington and compact officials since then have affirmed that policy.

Southeast Compact. The last of the three major multi-state-controlled commercial disposal facilities in operation through 1992, and the only one currently accepting Massachusetts LLRW, is located in the Southeast Compact region, in Barnwell, South Carolina. A more detailed description of this shallow land burial site can be found in Appendix 1A of Chapter 1.

Joining South Carolina in the compact are Alabama, Florida, Georgia, Mississippi, North Carolina, Tennessee, and Virginia.

In 1990, the Barnwell site operator, Chem-Nuclear Systems, Inc., submitted its Interim Site Closure and Stabilization Plan for review by South Carolina. Approval was granted by the State to begin partial closure of the southwestern portion of the site, an area of about 15 acres.

As noted, the South Carolina Legislature adopted a law in mid-1992 allowing Barnwell to remain open to Southeast Compact region generators until 1995, and to out-of-region generators through June, 1994, under certain conditions. Once the Barnwell site ceases operations, LLRW from the region will be sent to the new North Carolina disposal facility, scheduled to open in 1996.

North Carolina Siting Progress

North Carolina hired Chem-Nuclear Systems, Inc. as its site developer and operator. In February, 1990, Chem-Nuclear announced possible sites in four areas of the State. The North Carolina Low-Level Radioactive Waste Management Authority reviewed Chem-Nuclear's pre-characterization reports and recommendations, and conducted public meetings to receive comments. In April, 1990, the Authority eliminated two of the favorable site areas from consideration, and designated two for detailed characterization: 2,800 acres in Richmond County, and 1,400 acres on the borders of Wake and Chatham Counties. In December, 1993, the authority selected the Wake County site as its "preferred" site. A license application was required by South Carolina law to be submitted to North Carolina regulatory authorities by Dec. 31, 1993. The site is projected to begin operations early in 1996.

Shallow land burial is prohibited by North Carolina law. The disposal technology approved by the Authority in March, 1991, is the integrated above-ground vault technology proposed by Chem-Nuclear and similar to the design in Illinois, Pennsylvania, and Connecticut.

Availability to Massachusetts Generators

Chem-Nuclear, the Barnwell site operator, would continue operating the Barnwell site as a national LLRW disposal site, if the current policy regarding discontinuance were changed.

As has been noted several times in this chapter, a 1992 South Carolina law enabled Barnwell to remain open to out-of-region generators through June 30, 1994. A contract between the Southeast Compact Commission and the Massachusetts LLRW Management Board was executed in November, 1992, allowing LLRW generators from Massachusetts to continue to send waste for disposal through June, 1994.

One of the major incentives for extending Barnwell's availability as a disposal site to out-of-region generators was financial: South Carolina is raising at least $37.8 million from surcharge fees. Another reason cited for keeping Barnwell open is the fact that the next Southeast Compact disposal site -- in North Carolina -- is not expected to open until early in 1996. In addition, that siting process needed an infusion of funds, which the new $220 per cubic foot disposal fees has provided. If additional revenues are sought by South Carolina or for the North Carolina siting effort, or if delays in facility licensing hold up the North Carolina siting process, so that LLRW generators in the Southeast Compact region will not have access to disposal, the possibility exists that the June, 1994, date could be extended. South Carolina's new access law requires Legislative approval for any extension.

In addition to the new law, a policy of the Southeast Compact Commission allows Massachusetts to apply for membership in the compact, as long as the Commonwealth were to agree to serve as the next regional facility (before North Carolina).

Southwestern Compact. California is the host state for the Southwestern Compact, which also includes Arizona, North Dakota, and South Dakota. A site in the Ward Valley, part of the Mojave Desert, was identified in 1988 by US Ecology, the State's site developer and operator. Site characterization was completed in June, 1989, and a license application was submitted to the California Department of Health Services in December, 1989. As an Agreement State, California will regulate the disposal facility, which is projected to open in late 1994, unless current legal obstacles change that schedule.

The State's facility license was approved in September, 1993.

The license review period was lengthened by discussions regarding the presence of an endangered species of tortoise present on the site, and by the regional EPA's request for a double liner under all disposal trenches. Such a liner system is an EPA requirement for any facility accepting mixed waste for disposal, which the California facility is not intending to receive. License approval was also delayed by a dispute involving siting procedures used in California. The hearing issue became the subject of intense political pressure by certain California federal legislators and groups opposed to any facility siting. Because the Ward Valley site must be transferred from the federal government to the State, siting opponents have repeatedly tried to stop the facility by stopping the land transfer, and calling for adjudicatory hearings.

In August, 1993, U.S. Interior Secretary Bruce Babbitt indicated that he was willing to sell the land to the State, but only if California would conduct a hearing on the suitability of the Ward Valley site. Governor Pete Wilson agreed to Babbitt's request. In late November, 1993, Secretary Babbitt postponed his final action to transfer the site, pending the outcome of a state court challenge in which the petitioners have recommended a similar evidentiary hearing before any land transfer occurs.

LLRW management officials in California believe the new hearing requirement will delay the siting efforts for a year.

For use at its site, California selected the shallow land burial technology with several "enhance-

ments." The enhancements augment a design based upon the shallow land burial site operated by US Ecology at Beatty, Nevada. They include the use of sand or concrete as backfill to fill void spaces between packages, rather than soil; trenches deeper than the 50-foot depth at Beatty; a multilayered 20-foot thick trench cover comprised of various earthen materials rather than the 6.5 foot thick cover of native soil; and separate trenches for Class B and C wastes.

Other disposal technologies, including above- and below-ground vaults, and earth-mounded concrete bunkers,[16] were evaluated by the State, and determined to be inappropriate to address conditions in the Mojave Desert.

The California site will accommodate 5.5 million cubic feet of A, B, and C wastes as classified by the NRC. NARM waste is not currently included in the disposal facility plans. The State is aggressively pursuing the same options for mixed waste disposal reported in the earlier section on the Central Interstate Compact site (Nebraska).

Availability to Massachusetts Generators

Southwestern Compact law does not prohibit Massachusetts from joining the region as a party state, or entering into a contractual arrangement with the compact, although a two-thirds majority vote of the compact commission is required for approval.

The Management Board, which continues to have discussions with California officials, received two formal communications on the issue of access to the California site. The first letter (December, 1989) indicated an interest in discussing a reciprocal arrangement whereby Massachusetts would accept all Southwestern Compact mixed waste, and California would accept all other Massachusetts LLRW.

The second letter (October, 1991) reported on the Southwestern Compact Commission's vote to prohibit out-of-region waste from its compact facility.

Texas Compact. Texas formed a new regional compact with Maine and Vermont in 1993, and is proceeding with the development of its disposal facility site in Hudspeth County. Governor Ann Richards signed the compact legislation into law in June, 1993. Before it takes effect, however, it must be approved by the Vermont Legislature and the U.S. Congress. The Maine Legislature gave its blessing in mid-1993, and the majority of voters in a Maine statewide referendum approved the compact on Nov. 2, 1993.

The compact language provides that Texas may not accept more than 20% of the Texas LLRW volume (estimated over the 50-year operation of the facility) from Maine and Vermont, combined. Maine and Vermont produce approximately that amount. The compact also requires that Maine and Vermont each pay a total of $27.5 million as an "entry" fee for access to the Texas site. Texas will receive $25 million from each state in two payments ($12.5 million when Congress ratifies the compact, and $12.5 million when the facility opens). In addition, Maine and Vermont will each pay $2.5 million in two equal installments for community assistance projects in Hudspeth County, and will pay one-third of the Texas LLRW Disposal Authority's expenses until the facility opens. Disposal fees for generators in all three states will be the same.

The 380-acre site in Sierra Blanca, Hudspeth County, was the second area of that county selected by the Legislature as the disposal facility location. The Texas Low-Level Radioactive Waste Disposal Authority was directed by the Legislature to identify a disposal site on state-owned land in a specific area of the State, Hudspeth County. In June, 1989, the Authority selected two potential sites and commenced site characterization.

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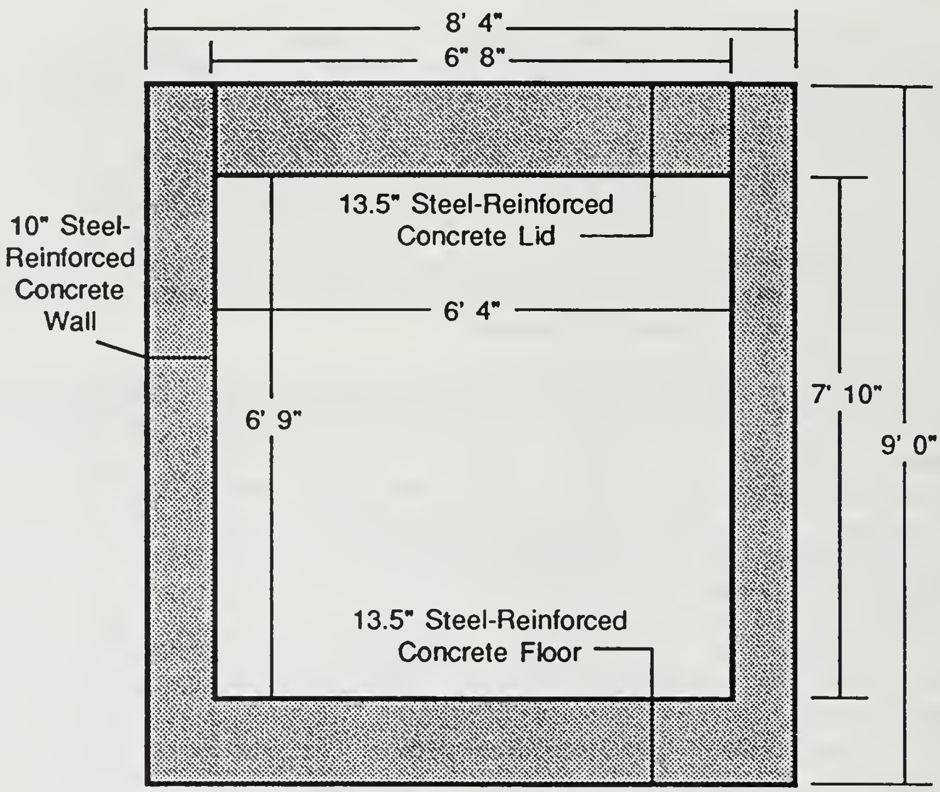
[16] These disposal technologies are described in Chapter 13.

In November, 1989, the Authority named one of the finalists, the Fort Hancock site, as the preferred site for waste disposal. The neighboring county of El Paso brought a lawsuit against the Authority, stalling progress. In late 1990, a district court in Hudspeth County ruled against the Authority on all but one count in the suit. The ruling enjoined the Authority from proceeding with siting activities on the Fort Hancock site.

An appeal was filed by the Authority in early 1990. However, that appeal was dropped following the approval by the Texas Legislature of a new law designating another location in Hudspeth County for site investigation activities, and allowing the State to accept out-of-state waste. Several states began discussions with Texas officials, including Massachusetts, Connecticut, Maine, and Vermont. At one point in 1992, Connecticut officials appeared before the Texas Legislature with an offer of a $100 million dollar entry fee, if Texas would accept Connecticut's waste. Texas declined. In December, 1990, Maine Yankee publicly offered to pay Texas $20 million for access to its new disposal facility.

Figure 15-D
Side View of Steel-Reinforced Concrete Canister
For the Texas Compact Disposal Facility



Source: Texas Low-Level Radioactive Waste Disposal Authority. "Facility Description and Canister Design." Pamphlet, June, 1993.

In April, 1992, the Texas LLRW Authority purchased a 16,000-acre site, known as the Faskin Ranch, in the Huspeth County location designated by the Legislature. Contractors began site characterization, which is expected to be completed by mid-1994. The Texas Natural Resources Conservation Commission has received a facility license application, and expects to complete its review by mid-1994. Following that review, a year of adjudicatory hearings will be conducted prior to any licensing decision. The Authority hopes to open the facility in 1996.

Texas will use modular concrete canisters placed in trenches 40 feet deep as its disposal facility design. The canisters will be cylindrical, nine feet tall, and approximately eight feet in diameter (see Figure 15-D). The canister walls will be 10 inches thick, and made of steel-reinforced concrete. When each canister is full, it will be pumped full of cement grout, and a 13.5 inch thick lid will be bolted into place.

Sixteen feet of soil and other engineered cover material will be placed on top. Mixed waste will be segregated in a separate vault. The facility will accept the NRC's Class A, B, and C waste, and is designed to take in LLRW for 30 years.

Availability for Massachusetts Generators

Until the passage of the 1991 legislation allowing Texas to compact only with small generating states, and then the 1993 law establishing the Texas-Maine-Vermont regional compact, a Texas disposal facility was viewed as a possible out-of-state solution for Massachusetts generators. That potential appears less likely in the future. While the "20% rule" applies only to Maine and Vermont, Texas officials have expressed their opposition to accepting waste from large-generating states. The Texas Legislature's decision not to include Connecticut in the new Texas Compact, and therefore not to receive Connecticut's $100 million dollar offer, is indicative of the feeling in Texas against out-of-region waste acceptance. In addition, Texas officials have expressed a similar concern identified by other states that are developing new LLRW disposal facilities. That concern involves an unwillingness to accept out-of-state or out-of-region utility plant decommissioning waste. Also, because the Texas disposal method will utilize concrete canisters placed directly into earth trenches, Texas LLRW officials have also expressed an unwillingness to take the large amount of tritium waste generated in Massachusetts.

New York. New York issued siting regulations in December, 1987, and identified 10 candidate areas in 1988. From that group, the LLRW Siting Commission selected five potential sites for further characterization, and plans to pick two or more sites for full, detailed characterization.

The State's siting activities were delayed in April, 1990, when opponents of the siting process used human chains and mounted horsemen to prevent access by Siting Commission officials to the candidate sites. Governor Mario Cuomo temporarily halted on-site pre-characterization work, and called for an evaluation of the site selection process.

This review led to the passage of amendments to New York's LLRW management act increasing public participation, and modifying the siting process. The New York Advisory Committee on LLRW was reconstituted and enlarged as a Citizens Advisory Committee to serve autonomously from the Siting Commission. Two new members were added to the Siting Commission, a social scientist and an environmentalist.

The changes in New York's LLRW management law require that the preferred technology for a disposal facility and technology-specific site selection criteria be developed before proceeding with siting.

New York law prohibits shallow-land burial.

The New York Siting Commission is prohibited by state law from considering the old West Valley LLRW disposal site in Ashford, New York. However, a lobbying effort undertaken by the State's LLRW generators resulted in a 5-0 vote by the Ashford Town Council in favor of removing the siting ban, and in support of a benefits package, proposed at $4-5 million dollars for the first year and approximately $2 million annually over the life of the facility.

Legislation has been submitted in the New York State Legislature every year since 1991 to allow the State's Energy Research and Development Authority -- the owner of West Valley -- with assistance from the Siting Commission, to initiate plans for interim storage, followed by site characterization, selection of a disposal technology, and licensure of the site as a disposal facility. That bill was still under consideration by the Legislature at the end of 1993.

While debate proceeds over the West Valley site, the New York Siting Commission has continued

its other siting activities.

Availability to Massachusetts Generators

New York law prohibits contracts with Massachusetts or other states seeking disposal. Discussions with New York officials about the possibility of eliminating that prohibition have resulted in candid opinions that a facility built in New York will serve only New York generators.

The legislation to authorize use of the West Valley site for New York waste stipulates that no out-of-state waste may be accepted into the facility. However, because Ashford officials were convinced to reverse their position against the West Valley site based on the compensation they would receive, a proposal for additional financial benefits, advanced by Massachusetts, may have a chance for favorable consideration. However, even if local officials were to support access for Massachusetts generators, the state law prohibition would have to be repealed through a vote of the majority of the New York Legislature.

Mixed Waste Disposal Capability

As noted in Chapters 8 and 13 of this Management Plan volume, disposal is not available for all types of mixed waste. Only one disposal site currently operates in the country, namely the Envirocare of Utah site in Clive, Utah. Because of restrictions on its license that limit the radioactivity of the waste (both non-mixed LLRW and mixed) it can accept, Envirocare cannot meet all the mixed waste disposal needs of generators in the nation.

Mixed waste disposal is aided by mixed waste treatment, and more companies are emerging to provide various treatment services. Most of the states involved in LLRW management activities, including Massachusetts, have expectations that DOE will identify one or more mixed waste disposal sites on their federal properties. Conversations between states and DOE are on-going; the National Governor's Association became involved in mid-1993 to assist in negotiations with DOE.

15.5 Future Capacity at the Proposed New LLRW Disposal Facilities

The capacity of any or all of these proposed new LLRW disposal facilities to accept Massachusetts-generated LLRW is difficult to predict with certainty. Each of the disposal facilities is being designed to accommodate a certain volume of LLRW over a period of years ranging from 30 to 50. However, each has a large buffer area that could potentially allow for expansion.

When inquiries have been made about the total waste volumes incorporated into each design, each state's officials have emphasized that since their facilities will be constructed in stages, each can be built to accept less waste annually, but operate for a longer period of years. For example, when Pennsylvania was initially selected as host state, the yearly volume of LLRW anticipated for disposal was 235,000 cubic feet. As a result of waste reduction activities, however, the Pennsylvania Department of Environmental Resources now estimates an annual capacity need of 150,000 to 180,000 cubic feet.

Pennsylvania law requires each generator to submit a plan with specific goals for volume reduction, resulting in continued waste minimization. However, Pennsylvania officials have indicated that they will factor projected minimization into the final design size of their facility, so that it will accommodate only the Appalachian Compact region.

Maine was an example of likely events in a small-volume generating state. Prior to joining the Texas

Compact, Maine financed its site identification costs through an assessment on a handful of Maine LLRW generators, with Maine Yankee paying 99% of the costs. If operational expenses were also funded completely by the Maine generators, Maine Yankee would have to pay most of the costs, passing these charges onto its rate-payers and resulting in electricity rates that may be unacceptable to the public and to state policymakers.

The small volume of LLRW produced in Maine should logically have guided that state to consider accepting out-of-state waste, in order to gain additional sources of revenue to cover facility-related expenses and to enhance the State's revenues. However, Maine was never willing to accept any other state's waste.

Federal Disposal Facilities

In addition to the existing state and private commercial disposal sites, and the new facilities being developed, LLRW disposal could be handled at facilities operated by DOE.

DOE has 13 active LLRW disposal sites. Figure 1A in Chapter 1 shows their locations. However, DOE will not accept commercial LLRW at any of its sites without the approval of the state in which the facility is located.

The sites capable of accepting commercial LLRW are situated in Idaho, Nevada, New Mexico, South Carolina, Tennessee, and Washington. Officials from South Carolina and Washington, which contain two of the existing commercial disposal sites, oppose using the DOE sites in their states, and are as concerned about waste being accepted at the DOE sites as they are with waste being accepted at their own state facilities.

Several states preparing to site new disposal facilities have been meeting with DOE to explore the possibility of the DOE sites accepting mixed waste. DOE has indicated its desire to negotiate some reciprocal arrangement in order for it to identify disposal sites for DOE-generated LLRW.

Triggering Emergency Access

Another option exists to make LLRW facilities available to Massachusetts generators. However, it is an option in name only, and is never expected to be approved.

The federal LLRWPAA of 1985 includes a provision that allows an LLRW generator or a state to seek "emergency access" to a non-federal operating disposal facility.

Section 6 of the Amendments Act authorizes the NRC to override access denial and grant waste generators emergency access. According to an NRC guidance document, in order to receive such access, a generator or state must petition the NRC and demonstrate that access is necessary to avoid a "serious and immediate threat to the public health and safety or the common defense and security, and that the threat cannot be mitigated by any alternative consistent with the public health and safety, including ceasing the activities that generate the waste."

NRC established criteria and procedures for granting emergency access in 10 CFR Part 62.[18] However, the agency, as well as Congress when it passed the Amendments Act, intended that emergency

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[18] Nuclear Regulatory Commission. "Supporting Statement for 10 CFR Part 62, Criteria and Procedures for Emergency Access to Non-Federal and Regional Low-Level Waste Disposal Facilities." Washington, DC, 1989.

access would be granted "only under rare and unusual circumstances." An NRC information notice dated Oct. 16, 1991, emphasizes the Commission's opinion:

> "The (Nuclear Regulatory) Commission remains strongly opposed to implementation of the emergency access provisions as an alternative for those States not meeting the milestones in the LLRWPAA and, accordingly, has no intent to implement these provisions to address such situations."

Indeed, the NRC estimates receiving an average of one request every three years from among the 23,000 licensed users of radioactive materials nationwide.

In addition, the NRC has made clear its policy that if emergency access were ever approved, the state receiving access would be required to accept an equal amount of LLRW from the state accepting Massachusetts waste at some later date. Therefore, emergency access would not avoid the need for disposal capacity.

15.6 Projections of Future LLRW Generation and Availability to Meet Future Management Needs

Over the last decade, Massachusetts LLRW generators have made significant progress in minimizing the volume of waste shipped for disposal. In 1991, 42,686 cubic feet of waste was accepted at the three commercial disposal sites in South Carolina, Nevada, and Washington. In 1992, volume jumped to 119,004 cubic feet shipped for disposal. A number of one-time decommissioning projects accounted for this huge increase, which is not expected to be maintained. These figures compare to the 303,182 cubic feet of LLRW shipped for disposal from Massachusetts in 1981.

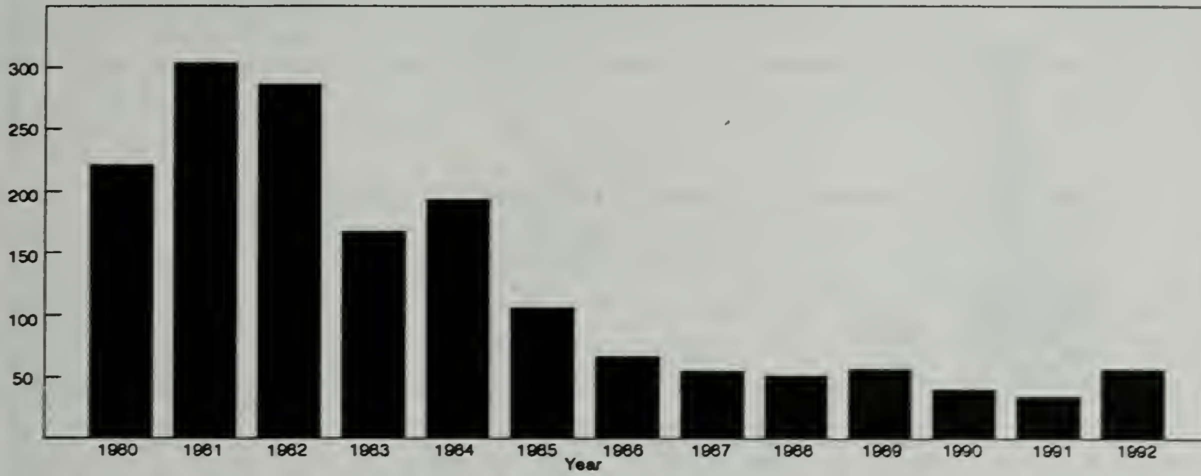
Figure 15-E shows the volumes of LLRW shipped for disposal since 1980. These volumes dropped dramatically in Massachusetts, as well as nationwide, after the passage of the federal LLRWPAA. That law, which took effect in 1986, allowed the three sited states of South Carolina, Nevada, and Washington to assess surcharges, in addition to other waste acceptance fees, on LLRW produced in compact regions and states that have no disposal facilities.

The LLRWPAA also allowed the three sited states to limit the volume of LLRW entering their sites from 1986 through 1992 to 19.6 million cubic feet, and to limit the volume the LLRW received from nuclear powered utility plants. The major portion of LLRW generated nationally results from commercial operations that use radioactive materials, not the utilities. This is also the case in Massachusetts, where the commercial category of LLRW shipped for disposal comprised 51% of the total in 1991, and 59.6% in 1992.

The minimization of LLRW volumes will continue to occur. There are four principal reasons for this assumption:

(1) The Southeast Compact Commission, which controls access fees to the Barnwell, South Carolina site, has set a surcharge of $220 per cubic foot for out-of-region waste disposed of at that site between Jan. 1, 1993 and June 30, 1994. If the site remains open after June, 1994, it is likely that the Compact Commission will maintain or increase the $220 surcharge. In addition, the Barnwell site operator, Chem-Nuclear, has raised its disposal charge to approximately $50 per cubic foot. These costs serve as economic incentives to force greater source minimization/elimination, and LLRW volume reduction.

Figure 15-E
LLRW Volumes Shipped for Disposal from Massachusetts Generators
(thousands of cubic feet)



Source: U.S Department of Energy, Low-Level Waste Management Program, 1992, and Massachusetts Low-Level Radioactive Waste Management Board, 1993.

(2) The costs of disposal facility site identification in most states/compact regions is being charged to the major generators in those states, i.e., the utility companies. These costs have provided an incentive to minimize waste.

(3) LLRW generators understand that minimizing waste production has positive environmental, social, and economic benefits.

(4) If generators have to store waste on site, volume minimization will reduce on-site storage locations and costs.

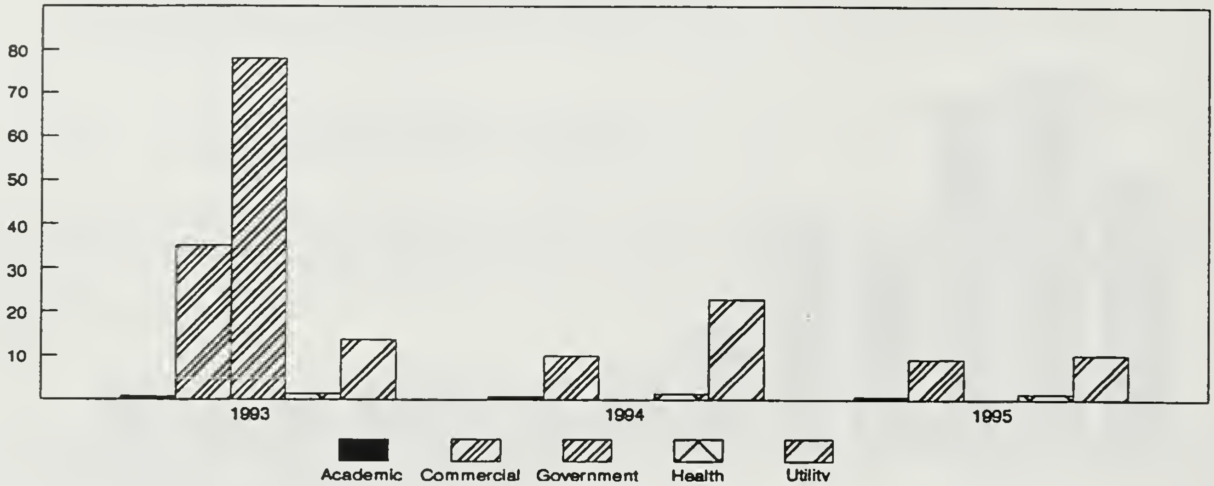
Massachusetts Projections of Volume and Radioactivity

LLRW will continue to be produced in Massachusetts. The question is, "how much" volume and activity in the LLRW will require storage, treatment, or disposal if no facilities to provide those services are available to Massachusetts generators?

According to data collected annually by the Management Board in surveying all radioactive materials users in the Commonwealth, the future generation of LLRW appears likely to level off after 1995, when total waste volumes are predicted to average between 20,000 and 25,000 cubic feet each year. These projections are shown in Figure 15-F, and are broken down by generator "category:" academic, commercial, government, health care, and utility.

Because of the difficulty of predicting radioactive materials use too many years beyond the present, the Management Board has asked for estimates only for three years after the survey-year. The projections provided by radioactive materials licensees may vary substantially as a result of unforecasted business plans, including business or product expansion, new business ventures starting in the Commonwealth, or business transfers to out-of-state locations. This possibility is particularly plausible for the commercial users of

Figure 15-F
Projections of LLRW Volume Requiring Disposal in a Licensed Disposal Facility
(thousands of cubic feet)



Source: Massachusetts Low-Level Radioactive Waste Management Board.

radioactive materials. Unlike the hospital, university, or utility users that are situated in specific locations for business reasons, many of the commercial radioactive materials licensees can more easily move their operations out of state, and thereby reduce the total volume and activity of the LLRW generated here.

These volume projections do not include waste volumes from the decommissioning of the Yankee Atomic Electric Company's reactor in Rowe. Yankee Atomic Electric Company officials predict that a total of 95,000 cubic feet of LLRW, comprising 192,000 curies of radioactivity, will result from decommissioning. However, some wastes from a component removal project are being shipped during 1993 and 1994, in order to take advantage of the available disposal site at Barnwell. Shipping that waste should reduce Yankee's total decommissioning LLRW to 80,000 cubic feet, and 10,000 curies.

The projected 20,000-25,000 cubic feet per year average also does not include any decommissioning waste produced as a result of the shutdown of Boston Edison's nuclear plant in Plymouth. Company officials estimate that a total of 288,000 cubic feet of volume, and 1,695,645 curies would be generated through decommissioning/dismantlement, but cannot predict now what market forces and safety factors may impact the facility as it approaches the end of its license period. While the Plymouth facility license expires in the year 2012, Boston Edison may seek re-licensure for up to an extra 20 years beyond that date.[19]

In addition, most of the waste assumed to make up the projected volumes for Massachusetts would not be suitable for disposal at the Envirocare disposal site in Clive, Utah. As noted, Envirocare's license restricts it to accepting low-radioactivity LLRW and low-activity mixed waste.

In addition, the estimate of 20,000-25,000 cubic feet annual LLRW generation does not include

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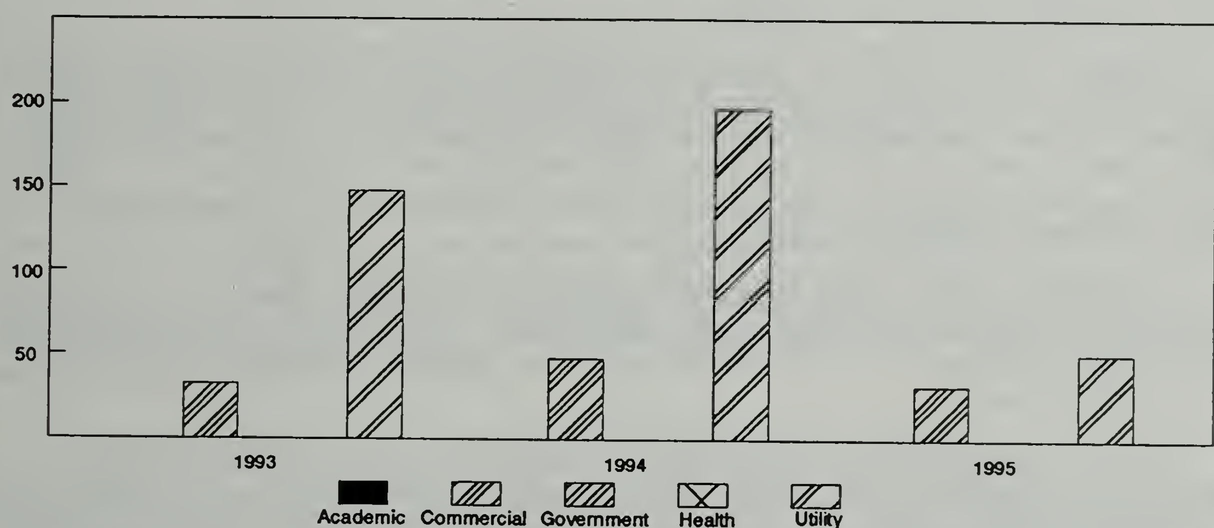
[19] Detailed information on decommissioning of all radioactive materials facilities, including Yankee Rowe and Pilgrim Station, is contained in Chapter 14.

increased production from existing or new Massachusetts businesses. The Commonwealth's current aggressive policy to attract new businesses, including many biotechnology firms that use radioactive materials and generate LLRW, may result in a larger average annual LLRW generation.

While the volume of LLRW is projected to equalize around 20,000-25,000 cubic feet a year after 1995, the activity of the waste is projected to fluctuate. The estimates supplied by LLRW generators show the activity of their projected waste to increase to 180,367 curies in 1993, and vary between 244,187 and 82,663 curies in 1994 and 1995. Figure 15-G shows generator projections of activity, by generator category.

Figure 15-G
Projections of LLRW Activity Requiring Disposal in a Licensed Disposal Facility through 1995
(thousands of curies)



[1] The projected increase in radioactivity in 1993 includes the anticipated shipment by Boston Edison of 225 cubic feet of activated metal components amounting to 50,000 curies.

Source: Massachusetts Low-Level Radioactive Waste Management Board.

Availability to Meet Future Management Needs

Earlier sections of this chapter describe the capacity of various in-state and out-of-state management options to handle LLRW produced in Massachusetts. The three main management options include storage, treatment, and disposal. They are not interchangeable, i.e., one cannot substitute for another.

Storage. Given the present guidelines of the NRC, which limit on-site storage to five years for all radioactive materials users, and questions of the appropriateness of on-site storage for lengthy periods of time, storage must be viewed as only a temporary option, and not a long-term solution.

It is apparent from the discussion in Chapter 12 and Section 15.2 of this chapter that all LLRW generators, both large-volume waste producers and small, can arrange for storage at their sites of generation for an interim period of up to five years. Unknowns include what extended time periods could be accommodated, and whether changes in federal regulations may occur to allow longer periods of

storage.[20] Even with the development of a centralized storage facility within the Commonwealth, the NRC currently is suggesting no more than five years of storage, and is not expected to extend that time period.

The use of out-of-state storage facilities is also very limited, but may have to be considered for a very small number of sites undergoing decommissioning that may be forced to remove stored waste off the sites. This scenario is not absolute, however. Some storage exists currently at the location of various processing operations. However, discussions with the companies that provide treatment indicate their past and present storage is a service offered to their clients, until the waste is shipped for disposal. While no formal policies have yet been developed, company officials stated an unwillingness to store large volumes or curies of waste.

If storage capacity is available, either in state or out of state, only as a short-term LLRW management solution, then other management options should be considered, including treatment to reduce the volume of LLRW, and disposal to permanently isolate the waste. Of course, treatment can be used in combination with both storage and disposal.

Treatment. The discussions in Chapter 11 and Section 15.3 of this chapter describe the capacity for LLRW treatment, both in state and out of state. Companies such as Scientific Ecology Group (SEG), in Oak Ridge, Tennessee, have suggested that they have the equipment that can process all the nation's LLRW, even though their current license limits the curies they are allowed to process annually. In addition to incinerating non-mixed LLRW to provide volume reduction, SEG has applied for a permit under RCRA authority to incinerate mixed LLRW, as well.

Other firms in addition to SEG are identified in Table 15-1 that have the ability to, and the interest in, treating LLRW and mixed waste generated in Massachusetts. All of these firms are already used extensively by Massachusetts LLRW generators, resulting in significant reductions in waste volumes ultimately requiring disposal.

The extent to which treatment continues to occur during the interim period from July, 1994, to the date Massachusetts identifies disposal capacity, relates to the costs of packaging and storing waste on site before disposal is available. LLRW treatment has been economically viable because of the high costs of disposing waste in South Carolina. When that disposal site is no longer available after June 30, 1994 (if Massachusetts generators do not lose access before that date), LLRW generators will have to evaluate the costs and benefits of shipping waste for treatment, and shipping it back to their companies for storage. In some cases, depending upon the amount of waste produced, the generator's storage space, and the type and size of packaging in which treated waste must be handled, it may be less expensive to package untreated waste and store it, on site, until disposal is available.

Treatment as a management policy, therefore, appears to be available to LLRW generators now and in the future. However, unless the treatment technology is able to eliminate the LLRW in its entirety, other management options, such as storage or disposal, must be considered in order for the Commonwealth to meet the mandates of federal law.

Disposal. The discussions in Chapter 13 and Section 15.4 of this chapter describe the availability of disposal facilities, both in state and out of state. It is clear from those discussions that LLRW generators

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[20] Nuclear-powered electric plants are allowed to store LLRW for the length of their license (up to 40 years) if they have an NRC-approved "safety analysis report" and the storage does not involve a "change in the technical specifications incorporated in the license or an unreviewed safety question." However, the NRC is in the midst of developing new policy that will likely limit the power plants to five years of LLRW storage, like all other commercial licensees.

in Massachusetts will not have disposal capacity available for non-mixed LLRW after June, 1994 (or perhaps sooner if access to Barnwell is terminated prior to that date). At the present, there is no indication that any of the facilities intended to be built in other states or compact regions will accept Massachusetts waste for disposal.

Moreover, a capacity shortfall already exists for mixed waste disposal. The only disposal facility permitted and licensed to accept mixed waste is the Envirocare disposal site in Utah, which is limited by its license to accepting certain low-activity LLRW.

15.7 The Need for Additional Facility Capacity

Chapter 111H requires this Management Plan to include a "finding as to whether there is a requirement for additional facility capacity to meet present low-level radioactive waste management needs or needs anticipated to arise within the next decade." [Chapter 111H, section 12(b)(5)] Based upon the analysis of present and future volume and activity of LLRW generation in the Commonwealth, and an evaluation of the availability of out-of-state storage, treatment, and disposal solutions, a need is determined to exist, as follows:

Storage facility capacity: No need exists to develop storage facility capacity for Massachusetts LLRW generators through June, 1994, and for the subsequent five years through June, 1999. This finding, however, does not fulfill the Chapter 111H requirement for a determination of need "anticipated to arise within the next decade," i.e., through the year 2004. The need for storage through 2004 could be accommodated by on-site storage, unless the NRC converts its "recommended" five-year on-site storage limit into a stringent regulatory requirement.

Notwithstanding this uncertainty, storage facility capacity is not considered to be necessary at this time, because on-site storage is available through June, 1999, or through five and one-half years of the next decade. For these LLRW generators that have chosen not to avail themselves of the Barnwell disposal site since January, 1993 (due to the high surcharge requirement), storage facility capacity would be needed as of January, 1998 (i.e., five years from January, 1993). Storage facility capacity may therefore be considered as an interim management solution, and may be evaluated for effectuation beginning, at the earliest, in January, 1998, only if:

- no disposal facilities will be available at that time for Massachusetts LLRW generators;
- on-site storage will not be authorized (by the NRC or by the Commonwealth under the Agreement State program) for an additional period of years; and
- negotiations with other states have resulted in or appear to be leading towards an agreement(s) to accept Massachusetts LLRW for disposal at some future date.

Treatment facility capacity: No need exists to develop treatment facility capacity for LLRW generated in Massachusetts at the present time or in the next decade. Facilities operating out-of-state have the capability to continue and to expand LLRW treatment activities.

The development of a treatment facility within Massachusetts will be considered only if:

- treatment is not available from out-of-state processors; and

- any disposal facility accepting Massachusetts LLRW requires treatment prior to disposal which cannot be accommodated by out-of-state processors.

No need exists to develop treatment facility capacity for mixed waste generated in Massachusetts at the present time or in the next decade. Some out-of-state mixed waste treatment facilities are capable of processing approximately 87% of the mixed waste generated in the nation. The remainder should be stored on site until a decision is reached by DOE regarding its present willingness to consider siting a mixed waste disposal facility for all mixed waste generated nationally, by both federal and non-federal generators.

<u>Disposal facility capacity</u>: A need exists for additional disposal facility capacity after June, 1994, due to the existence of the following conditions:

- The commercial disposal site in South Carolina is not expected to be available to Massachusetts generators;

- There are no licensed disposal facilities operating in Massachusetts that can dispose of the 20,000-25,000 cubic feet of LLRW that is predicted to be generated annually after 1995, as well as approximately 450,000 cubic feet of decommissioning wastes from the State's two nuclear-powered plants and other radioactive materials users, in a manner protective of the public health, safety, and the environment;

- None of the states or compact regions elsewhere in the nation that are currently in the disposal facility planning, design or development stages have indicated a willingness to accept Massachusetts waste;

- Federal law mandates that all states accept the responsibility for LLRW disposal as of Jan. 1, 1993; and

- Radioactive materials licensees -- hospitals, universities, manufacturers, biotechnology firms, environmental engineering firms, utilities, and others -- all depend upon the regulated use of these materials, producing over 36,000 jobs and over $3 billion dollars of benefit to the Massachusetts economy. The economic advantages of retaining these licensees in Massachusetts is another justification for the need for facility capacity. The millions of dollars that licensees spend to manage LLRW out of state could be used to provide jobs and business expansion within the Commonwealth.

<u>Capacity Need versus Siting Decision</u>

The determination that a shortfall exists in disposal capacity now and within the next decade; and the determination that a need for storage facility capacity will exist by the second half of the decade, does **not** automatically result in a decision to site a disposal or storage facility within Massachusetts. That decision can only be made by the Management Board pursuant to the provisions of Chapter 111H, section 17. The requirements of section 17 provide that the Management Board may initiate facility site selection only if it determines, by a two-thirds vote, that it is "necessary and appropriate to proceed with site selection." The Management Board may take a vote on this issue <u>only</u> if:

(1) the Board has adopted a Management Plan which incorporates a finding that a requirement exists for additional facility capacity to meet current needs or those of the next decade;

(2) the Department of Public Health has adopted regulations to implement a program for radioactive materials minimization, LLRW volume minimization, and storage for decay by generators;

(3) the Department of Environmental Protection has adopted criteria for selecting any "superior site,"[21] guidelines for applying such criteria, and procedures for implementing a site selection process;

(4) the Management Board has adopted regulations governing the selection of facility operators; and

(5) the Department of Public Health (DPH) has adopted regulations for facility licensing, development, operation, closure, post-closure observation and maintenance, and institutional control (i.e., the period potentially lasting 500 years when a facility is maintained and monitored after closure).

15.8 Options to Consider in Meeting Facility Capacity Needs

The Management Board has evaluated the full range of options for managing LLRW and resolving the disposal facility capacity shortfall which will occur after June, 1994, and the storage capacity shortfall that will occur, at the earliest, in January, 1998. Factors affecting the determinations of need, as well as options that include one group of decisions "not to site" a disposal or storage facility within the Commonwealth, and a second group "to site," have been aired through public discussion on the draft of this Management Plan. All options have encouraged public reaction, and inspired public debate.

Storage Facility Capacity

Section 15.7 of this chapter points out that every sign indicates the Commonwealth's LLRW generators can provide for on-site storage until July 1, 1999 (assuming access to the Barnwell facility lasts through June, 1994) or until Dec. 31, 1997 (assuming generators did not utilize the Barnwell disposal site). While the completion of on-site storage within these time periods does not fulfill the Commonwealth's needs for the next decade, the time frame required to be considered by Chapter 111H, storage facility siting is recommended as an interim solution only, in order to meet the anticipated capacity shortfall. The following factors affect this recommendation:

- A centralized storage facility is not a substitute to long-term LLRW disposal;

- The operating period that would be granted by an NRC license (or a DPH license, were Massachusetts an Agreement State) is uncertain. As has been stated, the NRC has consistently opposed storage beyond five years, and will not authorize what they regard as "de facto" disposal.

- While the ability of LLRW generators to store on site does not provide for their storage needs for an entire decade, it is not certain whether NRC would refuse to re-license radioactive materials users in the Commonwealth, thereby prohibiting on-site storage for an additional few years. Similarly, if Massachusetts were an Agreement State and the re-licensure responsibility fell on DPH, it is not certain whether DPH would refuse to license the users of radioactive materials in the State, forcing them to discontinue their use of these materials.

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[21] A "superior site" is defined by Chapter 111H as being any site selected by the Management Board, following the process of detailed site characterization.

Extending existing NRC or DPH licenses to Massachusetts LLRW generators cannot be compared to the NRC's (or DPH's) actions on the licensure of a long-term storage facility. The former can be justified in terms of legal, environmental, and economic responsibility over waste that has already been, and continues to be generated. The issues of jobs, economic benefits to the Commonwealth, and benefits to Massachusetts citizens from the use of radioactive materials, are all elements which comprise such a justification.

The latter (i.e., NRC or DPH licensure of a long-term storage facility that would operate beyond NRC's current allowable five-year storage period) can be disallowed by these licensing agencies on the grounds that more permanent solutions (e.g., disposal facility siting) are available to the Commonwealth.

This recommendation will be reviewed in connection with the annual review of this Management Plan, required pursuant to section 12 of Chapter 111H.

Options for Storage Needs

The options for addressing storage capacity needs are divided into two categories, (1) non-siting and (2) siting options. The advantages and disadvantages of each are identified below.

Non-Siting Options to Address Storage Capacity Needs

Option 1: Require all LLRW generators to arrange for storage on their premises for the most extensive time period authorized by NRC (or DPH, if Massachusetts is an Agreement State).

This option ensures that after the Barnwell disposal site has ceased to be available to Massachusetts generators, LLRW will be stored on their premises according to the conditions of their licenses, and under the control of trained employees, with routine inspections by NRC (or DPH).

This option is inexpensive to the Commonwealth, in comparison to other LLRW management choices. However, its expense to LLRW generators could be significant, especially if storage areas have to be developed and maintained at some cost for an interim period, and generators are later required to finance disposal solutions for the long-term.

On-site storage has its drawbacks to the Commonwealth, as well. On-site storage is not expected to be authorized for more than five to ten years; therefore this option Is only a short-term solution for the State to address the mandates of federal law. In addition, storage of waste types and concentrations of radionuclides not normally stored for such a time period, at approximately 100 sites around the Commonwealth, could potentially result in fires, mishandling accidents, greater occupational exposures, and other problems identified in this Management Plan.

Siting Options to Address Storage Needs

Option 2: Site a centralized storage facility for Massachusetts LLRW generators, only.

Centralized storage within Massachusetts may be a means of holding waste in a single, environmentally-sound location, because an out-of state disposal solution will not be available until after the period of time allowed for on-site storage. For example, if Massachusetts were to reach an agreement with another state to provide for disposal of Massachusetts-generated waste at some explicit future date, a decision to site an interim centralized storage facility could be the appropriate management action.

This choice is only an interim option, however. It is questionable how long storage in a centralized storage facility would be allowed. The NRC currently discourages more than five years of on-site storage, and is not expected to extend that time period, either for individual generators or for centralized facilities.

In addition, costs of siting, licensing, developing, operating, etc. a centralized storage facility would be especially high, considering that such expenditures would provide only a short-term LLRW management solution.

Option 3: Site a centralized regional storage facility.

The advantages and disadvantages of this option are similar to Option 2. An additional disadvantage is the potential added public opposition that might result from a facility built to handle not just Massachusetts LLRW.

Financial support for storage facility siting, development, operation, closure, post-closure, and institutional control costs may be available from LLRW generators located in other states. On the other hand, such financial benefits may not be forthcoming, due to cost analyses undertaken by these generators comparing their individual on-site storage expenses to their share of the financing of a Massachusetts centralized storage facility.

Treatment Facility Capacity

With the determination in section 15.7 of this chapter that no treatment capacity shortfall exists for the present or the next decade, and the emergence of new treatment companies able to process mixed waste, there is no need for the Commonwealth to consider siting an LLRW treatment facility. This decision will, however, be re-evaluated along with the annual Management Plan review, and the status of out-of-state treatment facilities will be continuously monitored.

Disposal Facility Capacity

A determination is made in section 15.7 of this chapter that Massachusetts LLRW generators will need disposal facility capacity at different times during the next 10 years (1994-2004), and beyond the decade, as follows:

(1) July. 1, 1994. This is the first time frame when a disposal facility for LLRW will be required. It is the date currently set by the Southeast Compact Commission when Massachusetts generators will lose access to the Barnwell, South Carolina site.

(2) Jan. 1, 1998. Some small-volume LLRW generators in Massachusetts decided not to ship their waste to the Barnwell, South Carolina, facility during the 18-month extended access period of Jan. 1, 1993 through June 30, 1994. Their reasons for not shipping waste during this time were small volumes of waste generated, the availability of on-site storage space, and the cost of disposal. The Barnwell disposal site surcharges for out-of-region waste were raised to $220 per cubic foot as of Jan. 1, 1993. With a 55-gallon drum holding 7.5 cubic feet of LLRW, just the surcharge for each 55-gallon package is $1,650. This fee does not include additional charges levied by the site operator. Generators that produce relatively small quantities of waste, and have the space to store it on site, may have chosen that option over paying these high disposal costs. For those who chose on-site storage, the five-year on-site storage "clock" began ticking on Jan. 1, 1993. Unless the NRC (or DPH Agreement State agency) extends its suggested five-year storage limit, these generators would require a disposal facility as of Jan. 1, 1998.

(3) July 1, 1999. This date assumes that all LLRW generated in the Commonwealth will be stored on-site for the maximum period of five years allowed by the NRC (i.e. from July 1, 1994 through July 1, 1999), but that extensions for a series of five year periods will not necessarily be approved.

(4) After July, 1999, and beyond 2004. Beyond July, 1999, LLRW generators within the Commonwealth will require disposal capacity. Waste already generated will have no place for disposal; LLRW that will continue to be produced -- even at lower total volume levels due to aggressive minimization programs -- will still require disposal. LLRW from the decommissioning of major radioactive materials users in the Commonwealth (such as the two nuclear-powered electric generating utilities and other large volume generators will require disposal.

As is pointed out in Chapter 14 on the impacts of decommissioning, some states that are presently planning to site LLRW disposal facilities have indicated no interest in accepting power plant decommissioned waste from outside their states or regions.

Options for Disposal Needs

The options for addressing disposal capacity needs are divided into two categories, (1) non-siting options, and (2) siting options. The advantages and disadvantages of each are identified below.

Non-Siting Options to Address Disposal Capacity Needs

Option 4: Continue to review the capacity needs of Massachusetts LLRW generators, monitor siting activities in other states, and discuss disposal options with other states.

This option maintains the "status quo" in Massachusetts, and gives the Commonwealth additional time to determine permanent disposal solutions while possible changes in national LLRW policy emerge. This option is the least expensive to the Commonwealth at the outset, as it does not involve any immediate expenditures for In-state facility siting or out-of-state "entry fees."

However, this choice is only an interim option; it does not resolve the State's long-term disposal facility needs. In addition, this option sends a message to other states that Massachusetts may not be willing to share in a regional solution, or may not ever be planning to initiate disposal facility siting. For a few small states surrounding Massachusetts, which have indicated their willingness to discuss financial incentives to assist Massachusetts' siting efforts In exchange for gaining access to a small regional disposal facility, the option of maintaining the status quo could lead to their finding other solutions, and shutting Massachusetts out of financially more conducive choices.

For example, the small-generating states of Vermont and Maine have been successful in gaining access to the Texas LLRW disposal facility. As has been noted, Massachusetts was also engaged in discussions with Vermont and Maine, regarding possible regional disposal solutions. These two states are now lost to any Massachusetts regional effort. Other small generating states like New Hampshire and Rhode Island, and the District of Columbia and Puerto Rico, may be willing to negotiate with Massachusetts for a small regional disposal facility. But if Massachusetts does not present a policy of forward movement, the option to negotiate with these states and regions may be lost, as they pursue other solutions to their LLRW disposal problems.

Option 5: Contract for continued access to existing disposal sites.

Massachusetts needs to take all actions possible to retain access to the Barnwell, South Carolina,

facility through June, 1994, and perhaps beyond. In addition to that action, this option proposes that the Commonwealth seek additional contracts for disposal access.

The desirability of such an option is obvious. Achieving a successful contractual arrangement with South Carolina or Washington -- both sites that remained open beyond 1992 -- would obviate the need for disposal facility siting within Massachusetts, and provide LLRW generators with the necessary disposal capacity for an extended period of time.

However, there are disadvantages to this option. Because of the laws and policies established in both South Carolina and Washington, the likelihood of a contract for long-term disposal is extremely slim. South Carolina's disposal site at Barnwell will be closed as soon as the new Southeast Compact regional site in North Carolina becomes operational, currently expected in 1996.

The possibility of a long-term contract with Washington State would depend upon changes to Northwest and Washington State laws, both of which prohibit a Massachusetts contract. Assuming such changes could occur, which is unlikely at this time, opposition to accepting out-of-region waste would still be a hurdle to overcome for the successful resolution of this option. Washington governors and state legislative leaders have been energetically opposed to allowing the importation of LLRW from outside their compact region. This policy is strongly supported by Washington citizens, who feel their state has done more than its share to provide LLRW disposal since the Hanford LLRW site opened in 1964.

Like option (4) above, this option eliminates the consideration of other options that may be more environmentally and economically sound. In addition, this option could be very expensive for LLRW generators, who would likely bear the financial burden of continually high waste disposal surcharges and fees.

Option 6: Negotiate a contract with a new "siting" state or region.

Another desirable option, this possibility appears unlikely based on current thinking in the states that are developing disposal facilities. As was noted in the previous section of this chapter in the discussions of availability of new sites to Massachusetts LLRW generators, contracts with other states are prohibited by the language of many of the regional compacts authorized by state Legislatures and Congress. In order for contracts to be a possibility, compact language would need to be modified. Legislatures and governors in the siting states and Congress would need to be supportive; legislative hearings would require public support as well. While the possibility arguably exists that such changes could be made in regional compact language, this option may be impossible as a practical matter.

However, state policies can change; new-siting states may at some time in the future recognize the financial advantages of accepting out-of-region waste. Their facilities, once operating, are likely to engender more public support as citizens accept them as workable technologies protecting public health and the environment. The issue of taking out-of-region waste, therefore, may became less of a local concern in the future.

If this option is chosen as the future course for Massachusetts, a schedule will be established for such contract negotiations. If Massachusetts cannot enter into a contract for long-term disposal by a date certain, this option will be reconsidered.

Option 7: Join an existing regional compact, initially as a non-host member state.

An earlier section of this chapter identifies the circumstances under which Massachusetts could join regional LLRW disposal compacts that are already in existence. In some cases, such as the Appalachian Compact, Massachusetts would have to be designated immediately as the host state for a regional disposal

facility, based upon the percentages of volume or activity of waste produced in Massachusetts versus Pennsylvania. However, other compacts (Northeast, Rocky Mountain, Southeast and Southwest) allow other states to join as non-host member states. While current policy in those states opposes such membership, political views are subject to change.

This option also assumes that at some unspecified date far in the future, Massachusetts would be selected in a rotation of compact member states to develop a regional facility.

This option, like (6), needs to be concluded within a specific, established period of time. If attempts to join other compacts as a non-host party state fail by such a deadline, then this option will be abandoned.

Option 8: Lobby Congress to change the federal law that assigned LLRW disposal responsibility to each state.

Congress has monitored activities to establish disposal capacity around the United States. Congressional representatives are aware of the huge expenditures of funds that have been committed to LLRW disposal. The possibility exists, therefore, that Massachusetts could establish a coalition of states wishing to transfer LLRW disposal authority back to the federal government.

DOE has 13 existing LLRW disposal sites at its research laboratories throughout the country. Congress potentially could assign DOE the full responsibility for commercial LLRW disposal.

While this option, if successful, has many advantages to Massachusetts and other states not wishing to site within their borders, it is an extremely uncertain strategy. All of the options identified so far, which depend upon some favorable outcome by another state or the federal government, are questionable strategies for Massachusetts to pursue, because their resolution is not within the Commonwealth's control. Depending upon the Congress to make such a major policy change, and then assuming that DOE will be successful in siting a national facility within the borders of one state, are difficult hurdles necessary to achieve this option, however.

As is recommended in proceeding with some of the other non-siting options identified above, a timetable will be established for successful Congressional or DOE action, and if not achieved, the option will be reconsidered.

Option 9: Contract with other countries to take LLRW for disposal.

There may be countries around the world that would consider accepting LLRW from Massachusetts generators in their own disposal facilities. The Commonwealth has discussed this option in a very preliminary fashion with representatives of the U.S. State Department and the NRC. No such countries have yet been identified.

Current policy in Washington discourages this option. However, federal officials have indicated that a proposal originating from another country, rather than from Massachusetts, would not necessarily be obstructed by the federal administration.

Option 10: Cease all use of radioactive materials in the Commonwealth that generate LLRW requiring disposal in a licensed LLRW disposal facility.

This option poses a number of legal problems for the Commonwealth. While the Management Board does not appear to have the statutory authority to stop LLRW generation, an argument could be made that DPH (when Massachusetts becomes an Agreement State) could potentially impose restrictions pertaining to source and volume minimization and on-site storage that effectively could stop the generation

of LLRW.

The provisions of Chapter 111H that grant DPH authority to establish a program of source minimization, volume reduction, and storage for decay, and to regulate on-site storage in connection with radioactive materials possession licenses, do not imply the use of this authority to cease all LLRW generation. The many environmentalists, citizens, and state and municipal officials involved in the discussions leading to the development and passage of Chapter 111H, and the Legislature, in enacting Chapter 111H, never discussed these DPH tasks in the context of their use to stop LLRW generation.

However, such an option could, perhaps, be implemented in the manner described above. Nevertheless, the legal ramifications of pursuing this option are immense, and the outcome, uncertain. The Commonwealth would no doubt be sued by one or more LLRW generators. Injunctions and normal delays in the litigation process would allow LLRW to continue to be produced.

In addition, this option of ceasing the generation of LLRW requiring disposal does not resolve the problem of managing and disposing of LLRW <u>already</u> generated and of handling LLRW that would result from the decommissioning of facilities ceasing their use of radioactive materials. As has been noted, Yankee Rowe has 95,000 cubic feet of waste that will require disposal due to its decommissioning activities. Other major LLRW generators, if they are forced to cease operations, will be required by federal or state regulation to decommission their sites. The resolution of this decommissioning waste is not addressed by Option (10).

Moreover, this option ignores the State's responsibility to an industry that provides products, services, and clinical procedures for the benefit of the public at large.

<u>Siting Options to Address Disposal Capacity Needs</u>

The following options address various in-state siting scenarios. Siting many types of facilities is difficult; an LLRW disposal facility would be no exception. But a siting decision may effect the State's attempt to be responsible and self-sufficient about managing a waste stream that could, if managed <u>improperly</u>, affect the public's health and the environment.

Each option had advantages and disadvantages. They should be compared with the options in the "non-siting" category in choosing the best strategy for the Commonwealth.

Option 11: Site a disposal facility in Massachusetts for Massachusetts-only LLRW, (with/or without an education/research center on techniques to eliminate or minimize radioactive sources and LLRW.

This option would provide the disposal capacity that will soon be needed by LLRW generators in the Commonwealth. This option would enable the facility site to remain reasonably small -- or the facility to operate for an extended period of years -- since the volumes of Massachusetts-produced waste are expected to average about 20,000 - 25,000 cubic feet a year (not including power plant decommissioning).

This option also suggests the possible establishment of a "Center for Excellence" or comparable educational/research activity to explore techniques for the elimination or minimization of radioactive sources and LLRW. Such a research center could be affiliated with a university, could experiment with the various types of LLRW shipped to the facility, and could provide educational programs to school groups, civic organizations, and users of radioactive materials. Such a facility could attract federal grants, and encourage innovation in waste minimization techniques.

The disadvantages of this option are obvious. Identifying sites for a number of locally-unwanted land uses, like prisons, solid and hazardous waste treatment facilities, and mental health operations, has not been

an easy task for Massachusetts or any other state. Concerns over the environmental suitability of LLRW disposal technology and public health protection would be important matters to address, as would the costs of facility site development.

The greatest disadvantage to this option, however, results from the provision of the federal Low-Level Radioactive Waste Policy Act (LLRWPA), that allows regional compacts to exclude waste from outside their region, but does not grant the same protection to a "go-it-alone" state. This means that if Massachusetts were to develop a disposal facility only for waste generated within the Commonwealth, other states could gain access, because Massachusetts cannot prevent the movement of waste in interstate commerce (including LLRW disposal) unless it is a member of a regional compact. This provision of the LLRWPA is what motivated Texas to change its plans from developing a Texas-only disposal facility, to a small regional facility.

Option 12: Site a small regional disposal facility within Massachusetts (with or without the education/research center component), and establish a compact with one or more states.

The disadvantages of this option are the same as (11) above. In addition, the public may be less willing to accept waste from other states.

One major advantage of this option is financial support to Massachusetts government and the State's LLRW generators. A regional compact would enable Massachusetts to receive funds from other compact member states to help pay disposal facility pre-development costs. The expenses of operating the facility and ensuring funds for institutional control and liability protection would be shared by generators inside and outside Massachusetts, thereby reducing the costs to the Commonwealth's businesses and institutions that generate LLRW. Sharing these costs would equalize the costs of waste disposal among the generators in several states, thereby eliminating some competitive costs between generators.

Another advantage of this option over (11) is the fact that Massachusetts could choose which out-of-state LLRW to accept, by selecting the states to participate in a compact. If the Commonwealth does not organize a compact, but instead develops a state-only disposal facility (11 above), Massachusetts could be forced by federal law to accept all out-of-state waste sent to the facility, under the provision in the LLRWPA which encourages states to form regional compacts, and allows regions of two states or more to exclude waste from outside that region.

This option has the similar advantage to option (11), in that it suggests the possibility of an educational/research center on source and LLRW volume minimization and elimination.

Option 13: Site a large regional facility within Massachusetts (with or without the educational/-research center component), and establish a compact with several large- and small-volume generating states.

The advantages and disadvantages are generally the same as (12) above. In addition, however, besides concerns that could be voiced about the facility size (in acreage) and volume and radioactivity of the waste proposed for disposal, it is likely that a greater level of concern would be expressed about waste transportation issues, effects of a large facility on greater numbers of people, etc., than about a state-only or small regional facility.

Option 14: Site a disposal facility and "contract" with other states.

The disadvantages of facility siting are the same for this option as for (11), (12), and (13), above. The advantages are generally the same as well, with the important exception noted in Option (11), that federal law does not allow a non-compact state to exclude out-of-state waste from its facility. If the

Commonwealth chooses not to establish a regional "compact," as suggested in Options (12) and (13), it may have some flexibility in negotiating agreements with various states for access. Contracts, however, are not as obligatory documents as compacts, which must be approved by the participating state Legislatures and by Congress. Compacts provide greater assurance that long-term obligations will be performed. And, as noted, the lack of a compact would expose Massachusetts to having to accept waste for disposal from other states.

Option 15. Site a disposal facility for Massachusetts-only LLRW, and enter into a compact with a "siting" state or compact region.

This option would eliminate the problem posed by options (11) and (14). Were Massachusetts to develop its own facility, and then compact with another state or region that had its own disposal site, the Commonwealth could exclude out-of-region waste, and not have to accept any "regional" waste for disposal, except its own.

Were Massachusetts to pursue this option with a "go-it-alone" state, it would have to consider a compact agreement with New York or Michigan; no other state is contemplating in-state facility siting on a "go-it-alone" basis.

If Massachusetts were to encourage such an arrangement with an existing compact region, it is unlikely that those regions already involved in siting activities would have any incentive to compact with the Commonwealth, since their existing compact agreements allow them to exclude out-of-region waste.

The only regional compact that might consider such an arrangement is the compact that already observes this policy: the Northeast Compact. Because neither Connecticut nor New Jersey, the two states that comprise the Northeast Compact, could agree on which state should host a regional disposal facility, both states decided to initiate siting in order to manage the disposal of their own LLRW. Both states have just begun a new "volunteer" process; no candidate or final sites have been identified to date.

Option 16: Join an existing regional compact and become the first host state.

This option might be available if Massachusetts were to join the Northeast Compact (Connecticut and New Jersey), and perhaps the Appalachian Compact (Delaware, Maryland, Pennsylvania and West Virginia).

Joining a large regional compact was an option considered intensely in the early 1980s when the Coalition of Northeastern Governors (CONEG) organized a group of 11 states to discuss compact creation. As is noted in Chapter 6 on regional compacting activities in Massachusetts, the Commonwealth opted not to join the proposed 11-state region because of its size and due to the likelihood that Massachusetts would be the first host state. However, Option (16) would allow the Commonwealth to receive financial support from states already in other compact regions, for example, the States of Connecticut and New Jersey. Because Connecticut has experienced serious siting difficulties, that state might well be willing to generously finance a regional site in Massachusetts.

Option 17: "Swap" waste streams between Massachusetts and another state.

This option suggests that Massachusetts would agree to site a facility for some sort of regional waste problem -- say LLRW -- and accept LLRW from another state. In exchange, the other state would agree to site a facility for a different regional waste problem -- say, solid waste -- and accept Massachusetts-produced solid waste into its facility. Under this option, two waste problems are resolved, and each state has had to site only one facility.

The disadvantages concerning siting issues are the same for this option as other siting options described. Another disadvantage results from a recent U.S. Supreme Court decision, in which the Court ruled that the State of Alabama could not discriminate against the acceptance of out-of-state hazardous waste. [Chemical Management, Inc. v. Hunt] This ruling may prevent two states from swapping LLRW and hazardous waste facilities since the state siting the hazardous waste facility may not be able to restrict access just to the two states involved in the swap. The major advantage is the resolution of two difficult waste issues, rather than just one, and the sharing of the solutions between two states.

Option 18: **Site a regional "mixed" waste disposal facility and negotiate a trade of all Massachusetts non-mixed LLRW for mixed waste from other states or compact regions.**

Because the volume of mixed waste produced in the nation is a small percentage of the total commercial LLRW stream, and an even smaller ratio of the mixed waste produced by the federal government's nuclear research program, the Management Board can continue to press DOE to establish a joint federal-commercial mixed waste facility at a DOE location.

However, because it may be unlikely that DOE could successfully site such a national facility within the next couple of years, an alternative is for Massachusetts to assume this responsibility. Even though the costs of mixed waste disposal would be significantly higher per cubic foot than the costs of building a non-mixed waste disposal facility, the small volume of mixed waste requiring disposal would signify a reasonably small facility for Massachusetts. The portion of Massachusetts LLRW that is mixed waste -- waste that contains materials listed as hazardous or that exhibit characteristics of hazardous materials, as determined by the EPA -- is generally 2-3%. In 1992, because of the quantity of high volume, low activity LLRW shipped for disposal due to various decommissioning projects, the mixed waste portion of the State's LLRW amounted to less than one percent.

The cost of developing a small mixed waste disposal facility for Massachusetts and a number of other states or compact regions could be offset by out-of-state entry fees. The ability of the Commonwealth to ship approximately 97-98% of its annual LLRW volume to another disposal site would be the major advantage of this option.

A disadvantage would be the real or perceived operational problems that mixed waste can cause, due to its hazardous contents or characteristics. The public may be less supportive of a facility built to dispose of both radioactive and hazardous waste.

Summary

Massachusetts, like other states that are addressing the LLRW management and disposal problem, must adopt one or more of these non-siting and siting options in order to proceed in a timely and organized fashion to ensure the public health and environmental protection of its citizens. The challenges will be significant, but with public participation and a spirit of cooperation between state officials and interested parties, these challenges can be overcome.

15.9 Disposal Facility Capacity and Size Specifications

The development of a disposal facility in the Commonwealth could proceed under a variety of scenarios, as described above. One of the implications of siting a facility is the required land that must be committed to the facility. This land requirement is affected by several factors, including:

- years of disposal facility operation;
- volume and types of LLRW to be accepted over the life of the facility;
- disposal technologies employed at the site;
- other activities allowed and implemented at the facility (for example, the establishment of a university-affiliated LLRW minimization research center); and
- whether a state-only or a regional facility is sited.

Chapter 111H requires that preliminary estimates of the minimum required facility capacity and size must be included in this Management Plan. The land use estimates were developed based upon certain criteria and available data with respect to the factors listed above.

Size estimates for four possible disposal facilities were developed. Two sizes would handle Massachusetts-only LLRW, and two would provide capacity for regional LLRW disposal. The major criteria and data used for all facility sizes are as follows:

(1) the facility would operate and accept waste for 30 years;

(2) total LLRW inventory was estimated based on data and projections of future waste quantities derived from the 1989, 1990, 1991, and 1992 Massachusetts LLRW surveys;

(3) decommissioning wastes available for disposal at the facility from two commercial power reactors were assumed to total 450,000 cubic feet of Class A, B, and C LLRW;

(4) a minimum of a 500-foot buffer zone would surround the facility on all sides;

(5) the disposal technology employed at the site <u>for all waste classes</u> would be retrievable concrete canisters within earth-mounded above-ground concrete vaults;

(6) no significant commitment of land would be required for other types of activities at the site not directly related to the disposal function. Sufficient land area would be available for office and laboratory space in connection with any affiliated activity, like an educational/research center to conduct studies on minimizing or eliminating radioactive sources and LLRW.

The first <u>Massachusetts-only</u> facility size also assumes an annual disposal volume of 20,000 cubic feet, to contribute 600,000 cubic feet of Class A, B, And C LLRW to the total site inventory over 30 years. The total site inventory from annual shipments and decommissioning would be 1,050,000 cubic feet.

The second <u>Massachusetts-only</u> facility size also assumes, for conservative design purposes, an annual LLRW disposal volume of 35,000 cubic feet, to contribute 1,050,000 cubic feet of Class A, B, and C LLRW to the total site inventory over 30 years, including non-power plant decommissioning waste. The total site inventory from annual LLRW shipments and decommissioning would be 1,500,000 cubic feet.

Similar criteria and data were used for estimating two regional facility sizes. The projections are based upon recent LLRW generation rates, and the volume of decommissioning waste from several facilities in these states. A <u>small regional</u> facility was estimated to require a disposal capacity of 2,400,000 cubic feet size (i.e., an additional 30,000 cubic feet per year over the second Massachusetts-only size option). This size reflects a minimum size regional facility that would include one or a few small generating states.

A large regional facility, which might serve several states, was estimated to require an annual volume of approximately 467,000 cubic feet, for a total site inventory of 14,000,000 cubic feet.

Minimum Facility Land Area

The minimum land requirements for these four in-state disposal facility options are estimated to be:

(1) Massachusetts-only = 100 acres;[22]

(2) Small in-state regional facility = 130 acres; and

(3) Large in-state regional facility = 420 acres.

The land-use estimate has been derived using the conservative criterion that all LLRW would be packaged and disposed of in the same type of disposal containers and disposal units. Therefore, the distribution of waste classes was not important to the land-use calculations. However, a rough estimate of the proportions of Class A, Class B, and Class C wastes was derived from the Management Board's annual surveys to illustrate the amount of LLRW of each disposal class that would require disposal. The proportions and volumes for 30-year state-only and regional facilities are summarized in Table 15-4.

Table 15-4
Disposal Facility Waste Inventory Projections
(volume in cubic feet)

Facility Type	Disposal Class			Total Site Inventory	Average Annual Volume
	A	B	C		
Minimum Size State-Only Facility					
Volume	966,000	63,000	21,000	1,050,000	35,000
%	92	6	2	100	
State-Only Facility					
Volume	1,380,000	90,000	30,000	1,500,000	50,000
%	92	6	2	100	
Small Regional Facility					
Volume	2,200,000	144,000	56,000	2,400,000	50,000
%	92	6	2	100	
Large Regional Facility					
Volume	12,880,000	840,000	280,000	14,000,000	466,667
%	92	6	2	100	
Source: Massachusetts Low-Level Radioactive Waste Management Board, November, 1993.					

[22] The two Massachusetts-only facility sizes did not significantly change land requirements.

Although the size estimates are considered reasonable and comparable to site sizes estimated and developed for other LLRW disposal facilities, they are based on preliminary data. A decision to site a disposal facility would require a reassessment based on a more thorough characterization of waste inventories; a decision on use of the facility as a regional facility; the size and nature of the out-of-state waste stream; and an evaluation of the site community's choice of disposal technologies.

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Chapter 16: The Economic Impacts of Facility Siting on a Site Community

16.1 Introduction

The American Planning Association, in a report prepared for the U.S. Department of Energy's (DOE) National Low-Level Radioactive Waste Management Program,[1] describes the challenge of low-level radioactive waste (LLRW) disposal facility siting in the following way:

> "Planning officials involved in activities surrounding the search for a suitable site ... face problems similar to those faced in the siting of prisons, power plants, airports, sanitary and hazardous waste landfills, and sewage treatment plants. Each of these facilities serves a diffuse regional need but seriously affects a local area. The three operating LLRW disposal sites (in South Carolina, Nevada and Washington),[2] for example, benefit hospitals, medical and research laboratories, and power plants throughout the U.S.; but communities that host these facilities must live with the health and environmental risks associated with the transport, loading and unloading, storage, and disposal of LLRW."

While there may be some risks involved in siting an LLRW storage, treatment, or disposal facility, these risks can be ameliorated by selecting the proper sites, and by utilizing facility designs, operating, and closure procedures which ensure the protection of the public health and the environment. The magnitude of such risks may be perceived to be great, but may not be large relative to risks from more familiar activities.

There are also risks involved in the use of radioactive materials by universities, hospitals, government agencies and industries that produce LLRW as a by-product of their operations. Federal and state governments stringently regulate radioactive materials and LLRW activities, in order to control the risks and

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[1] American Planning Association. Use of Compensation and Incentives in Siting Low-Level Radioactive Waste Disposal Facilities. DOE/LLW-42T. U.S. Department of Energy, National Low-Level Radioactive Waste Management Program, Idaho Falls, Idaho, April, 1985.

[2] When this statement was made in 1985, there were three commercial disposal sites accepting the nation's LLRW, and located in Barnwell, South Carolina; Beatty, Nevada; and Hanford, Washington. Since that time, however, the Beatty site has closed (on Dec. 31, 1992), and the Hanford site has ceased accepting LLRW from outside the Northwest Compact and Rocky Mountain Compact regions (as of Dec. 31, 1992). The only LLRW disposal facility accepting LLRW (but not mixed waste) that is currently available to Massachusetts LLRW generators is the site in Barnwell, South Carolina. That site is scheduled to cease accepting waste from outside its region on June 30, 1994, unless the South Carolina Legislature extends its availability. Another relatively new LLRW disposal site, located in Clive, Utah, and run by Envirocare of Utah, Inc., accepts "high volume, low activity" LLRW, such as soil, building rubble, debris, etc. The Envirocare site is not licensed to accept most of the LLRW types generated in Massachusetts or the nation.

to enable the benefits of these materials to enhance and improve the community at-large.

There are risks involved in many activities of our advanced, industrialized society, such as taking airplane trips, driving automobiles, and smoking cigarettes. The difference between these risks, and the risks related to LLRW facilities, is that the public "chooses" the first list of risks, whereas they may not always choose to host an LLRW facility.

The risks involved in siting LLRW facilities include those associated with:

- storing LLRW;
- transporting the waste;
- loading and unloading LLRW;
- the potential for radiation exposure to facility workers;
- the potential for radiation exposure to the public living or working near such a facility;
- the potential for radioactivity to contaminate the environment;
- non-nuclear occupational hazards;
- the potential for other non-nuclear environmental impacts from construction, operation, and transportation activities;
- LLRW treatment;
- LLRW disposal; and
- facility closure and institutional control.[3]

As is discussed in Chapter 17 on property value protections for LLRW facilities, the public also perceives that there are other disincentives to siting an LLRW facility in addition to the above-stated risks. These include concerns that:

- in the case of LLRW disposal, the facility site would be unavailable for any other use during both the periods of operation and institutional control, potentially lasting several hundreds of years;
- the facility may or may not encourage economic development;
- property values to the homes nearby may be impacted;
- the network of roads leading to and from the facility may sustain increased traffic, and require additional maintenance; and
- additional costs to municipal services may be required to provide fire and emergency response, facility inspection, and monitoring.

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[3] "Institutional control" is the period following facility closure when continued observation, monitoring, and facility care occur, for up to 100 years or longer in the case of an LLRW disposal facility.

On the other hand, the consequences involved in failing to resolve the LLRW problem are also significant. Lack of centralized storage, treatment or disposal capacity can:

- prevent state government from managing LLRW in the most effective, public health- and environmentally-protective manner;

- create an incentive for illegal dumping of radioactively-contaminated waste;

- create potential public health or environmental problems if the waste must be stored on site, as characterized by the past President of the American Health Physics Society, who, in a published article, has suggested "there may conceivably be fires involving such materials, spills, loss of control, even orphan waste when marginal businesses fail".... as well as "the added work risk due to the need for multiple handling and repackaging prior to final disposal;"[4]

- cause users of radioactive materials that produce LLRW, such as hospitals, biotechnology firms, and others, to cease applications of these materials. Hospitals may be forced to cease or curtail diagnostic and treatment procedures for cancer patients and others, as did occur in 1979 when the three disposal sites available in the nation at that time were closed for a while. While hospitals are not likely to relocate, biotechnology firms and other industries can move more easily, and may be forced to relocate to states where storage, treatment, and disposal capacity is available. Such relocations will seriously affect jobs, taxes, and billions of dollars of economic benefit to the Massachusetts economy which result from these activities;[5] and

- discourage new business and industry from locating in Massachusetts at a time when new jobs and economic growth are vital to recovering from the national recession.

Risks are considered at varying levels of concern by different groups. A recent study by the U.S. Environmental Protection Agency (EPA), which is shown in Table 5-4 of Chapter 5, indicates that 67% and 58%, respectively, of the American public is "very seriously" concerned about active hazardous waste sites and radiation from radioactive wastes. However, neither issue is on the EPA's list of greatest environmental and public health concerns, because that federal agency believes other environmental problems, (which are also ranked high by the public -- such as ozone depletion, industrial air pollution, and chemical exposure in the workplace) -- are more serious.

While public opinion surveys show that no one wants LLRW in his "backyard," almost everyone agrees that there is a need to site certain types of LLRW facilities. This chapter assesses the various economic impact payments provided by states that are currently involved in the process of siting LLRW disposal facilities,[6] and makes some recommendations for Massachusetts policy in this area.

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[4] The concern over on-site storage by thousands of radioactive materials licensees nationwide was expressed in an article in the American Health Physics Society's August, 1990, "Newsletter" by Society President Francis X. Masse of MIT. A longer excerpt of his statement appears in Chapter 12 of this volume.

[5] Chapter 4 describes a survey recently conducted by the Low-Level Radioactive Waste Management Board regarding the economic benefits in jobs and revenues to the Massachusetts economy from the use of radioactive materials. The data indicate that over $3.035 billion dollars of economic benefit and over 36,000 jobs result from this activity.

[6] No states are siting centralized storage or treatment facilities at this time. All their economic impact and compensation programs are geared to LLRW disposal.

16.2 The Differences between "Compensation" and "Impact Payments"

Two categories of impact disbursements are generally available. "Compensation" offsets burdens borne by the site community, and "impact payments" provide monies, services, or other tangibles over and above the municipality's expenses in having a facility within its borders.

Both types of impact disbursements to a site community can be monetary payments. Both types can also come in the form of other tangibles. There is often a fuzzy distinction between these two types of impact disbursements, because some persons will describe all monies or services received by the site community above and beyond the municipality's actual costs of providing services to the facility as "impact payments," whereas other individuals will call such receipts "compensation."

Compensation frequently includes one or more of the following:

- grants to assess the impact of a proposed facility on the municipality;
- payments for losses of property taxes from the land used for the facility and a buffer zone, since that land would be owned by the State;
- monetary payments to compensate for health and environmental risks;
- community-wide health monitoring programs;
- property value guarantees;
- payments or equipment for emergency services;
- road improvements;
- insurance or contingency funds;
- funds to monitor facility operation and closure; and
- other types of compensation identified by the site community.

Impact payments can include:

- purchase by the State or facility operator of park land or other lands for public purposes;
- representation on the facility governing board;
- payments for municipal services such as schools, libraries, swimming pools, etc.;
- agreements by the facility operator to hire "locally;"
- agreements by the facility operator to purchase supplies, materials, and equipment locally;
- lump-sum payments;
- assistance in enhancing the economic development potential of the community;

- "tipping fees" based on the amount of waste (or other factors) accepted at the facility;

- local authority to shut down the facility under certain circumstances; and

- other impact payments identified by a site community.

Compensation and impact payments to local communities are significant components of the overall cost-benefit analysis used in siting an LLRW storage, treatment, or disposal facility. Just as there are benefits and costs to society as a whole associated with the use of radioactive materials and LLRW management, there must also be appropriate benefits to offset actual and potential costs to local communities. If there is an overall benefit to the larger society driving a decision to site a facility, there should be an overall benefit to the local community, as well.

No facility should be sited unless it can be demonstrated to be protective of the environment, and safe to the workers who are employed there and to the public who lives nearby. If those criteria are accomplished satisfactorily, then a community has every right to receive compensation and impact payments, to offset the cost side of the cost-benefit equation.

16.3 What States are Doing to Provide Compensation and Impact Payments

As can be seen from the summary in Table 16-1, most states that are siting LLRW disposal facilities have established financial compensation and impact payment policies. In some cases, these policies are similar to those provided for hazardous waste facility siting. However, in other cases, the LLRW site community impact payments and compensation packages are more expansive. This situation may be due to the fact that federal LLRW laws set deadlines for state action, and back them up with stringent penalties for non-compliance. Federal hazardous waste law, on the other hand, does not impose the same kind of harsh penalties against the states.

In every case, the payments shown going to the site community have "no strings attached," and can be used by the municipalities to fund facility-related activities such as inspection and monitoring, or to finance other needed public services.

A relatively new type of compensation is property value protection. This subject is covered separately in Chapter 17. Massachusetts law allows negotiations for property value protections, as well as other compensation and impact payments, as part of the agreement developed between the State, the facility operator and the site community for the "comprehensive operating contract." The Management Board has established a program of property value guarantees; the details can be found in Section 17.5 of Chapter 17.

16.4 Statutory Provisions for Compensation and Impact Payments in the Massachusetts LLRW Management Act

There are a number of stages in the siting of an LLRW storage, treatment, or disposal facility when compensation and impact payments to the site community are subjects of consideration. Some of the arrangements for compensation are tied to various provisions for public participation, and are therefore

Table 16-1
Summary of Various States' Provisions for Compensation and Impact Payments for LLRW Disposal Facility Siting[1]

State	Payments to State	Payments to Site Community	Payments to County	Payments to Abutting Community	Payments to Individuals	Authority[2]	Notes
California	No	No	No	No	No		The state siting authority is considering lump sum payments to the site community. California LLRW generators' group (CalRad Forum) has proposed a $10 per cubic foot fee to fund site community impact payments for the local school district
Texas	$55 million compact "entry" fee to be paid jointly by Maine and Vermont		10% gross operating revenues	No		S	Monies paid to county must be distributed to various taxing entities within county, including site community
Vermont	No	Impact fees to be determined after study by Siting Authority	No	No	No	S	Vermont's action to join a compact with Texas and Maine will require the payment of compensation to Hudspeth County, Texas

Table 16-1
Summary of Various States' Provisions for Compensation and Impact Payments for LLRW Disposal Facility Siting[1]
(continued)

State	Payments to State	Payments to Site Community	Payments to County	Payments to Abutting Community	Payments to Individuals	Authority[2]	Notes
Connecticut	No	A portion of: 10% of gross operating revenues if receipts are < $1.25 million, or 5% of gross operating revenues if receipts > $1.25 million but < $2.5 million, or 2.5% of gross operating revenues if receipts are > $2.5 million, plus payments in lieu of property taxes. In addition, towns volunteering to host site would also receive: $250,000 ($300,000 to host regional site); $100,000 if 1st to enter volunteer program ($150,000 if 1st to volunteer regional site); $250,000 after 6 months of good faith negotiating ($300,000 if regional site); $1 million if voters approve site and agreement by referendum ($1.5 million if regional site); negotiated "initial" payment (not < than $2 million) and negotiated "annual" payment (not < than $1 million)	No	See proportionate language for payments to site community. In addition, if regional group of towns volunteer a site, abutting towns (up to 10) each receive: $200,000 to volunteer; $50,000 if 1st region to volunteer; $200,000 after 6 months of good faith negotiating; $500,000 if voters approve site and agreement in referendum; and negotiated "initial" and "annual" payments	Operator must negotiate "mitigation measures" not to exceed $150,000 plus operator guarantee of property values within 2 miles of facility from time of site selection through 5 years after operations begin	S[3]	Connecticut Siting Council determines proportions paid to each community. "Mitigation measures" of $150,000 may be payments to the site community, or to individuals
Illinois	No	$2.15 million per year[4]	No	No	Negotiated compensation includes impact mitigation and property value guarantee[4]	D	Payments made at discretion of Department of Nuclear Safety[4]

Table 16-1
Summary of Various States' Provisions for Compensation and Impact Payments for LLRW Disposal Facility Siting[1]
(continued)

State	Payments to State	Payments to Site Community	Payments to County	Payments to Abutting Community	Payments to Individuals	Authority[2]	Notes
Massachusetts[5]	No	Payments in lieu of property taxes plus 4% of annual gross operating revenues, or $240,000 if less than 100,000 cubic feet accepted into facility, or $320,000 if between 100,000 and 199,000 cubic feet accepted into facility, or $400,000 if 200,000 cubic feet or more accepted into facility, plus $150,000 to be paid when the facility commences operation and ending 5 years often issuance of facility license, plus funds to Community Supervisory Committees (CSCs) to review studies, monitor detailed site characterization, etc. Membership on facility governing board after "superior" site is selected	No	1% of annual gross operating revenues or $60,000 if less than 100,000 cubic feet accepted into the facility, or $80,000 if between 100,000 and 199,000 cubic feet accepted into facility, or $100,000 if 200,000 cubic feet or more accepted into facility	"Negotiatedagreements" may include reimbursements for road maintenance or reconstruction, other imported infrastructure costs, property value guarantees, etc.[6]	S	Payments in lieu of property taxes begin with the purchase of the facility property, and continue throughout institutional control. The amounts shown here will be apportioned among each "site" and "neighboring" community. Funding to CSCs occurs during pre-operational stages. "Negotiated agreements" may be paid to the site community or to individuals
Michigan	$500,000 from facility user fees, plus minimum of $400,000 to Michigan Environmental Response Fund, plus minimum $200,000 to Clean Michigan Fund plus fees from Class C disposal	$800,000/year from user fees, plus $400,000/year (from a portion of a 20% surcharge on disposal fees), plus negotiation allowed for "reasonable direct costs associated with disposal site," including payments in lieu of property taxes	$300,000/ year	$400,000/year (from 20% surcharge)		S	All fees from Class C disposal deposited in a "Clean Michigan Fund." A 20% surcharge on disposal fees will be divided by the host and neighboring communities

Table 16-1
Summary of Various States' Provisions for Compensation and Impact Payments for LLRW Disposal Facility Siting[1]
(continued)

State	Payments to State	Payments to Site Community	Payments to County	Payments to Abutting Community	Payments to Individuals	Authority[2]	Notes
Nebraska	No	$1 million/year, plus $300,00 community improvement grant only during site characterization, plus $100,000 to local monitoring committee, plus training and equipment provided for emergency response	$1 million/year	No		S	
New Jersey	No	5% gross operating receipts	No	No	LLRW Siting Board may negotiate financial or other impact payments with the site community	S	If a municipality hosts an LLRW facility, it is exempt from hosting a hazardous waste or solid waste facility. Negotiated impact payments may be paid to host community or to individuals
New York	No	Payments in lieu of property taxes, plus other payments yet to be determined	No	No	No	S	New York law requires that the Legislature pass a program for incentives and compensation to a sited community. Two ad hoc committees have made recommendations

Table 16-1
Summary of Various States' Provisions for Compensation and Impact Payments for LLRW Disposal Facility Siting[1]
(continued)

State	Payments to State	Payments to Site Community	Payments to County	Payments to Abutting Community	Payments to Individuals	Authority[2]	Notes
Nevada		No	No	No			
North Carolina	Radioactive waste tax from generator fees (% to be determined by Legislature)	Payments in lieu of property taxes; reimbursements for loss in ad valorem taxes due to decreases in property values directly related to facility	2.5% gross operating revenues	No	Reimbursement for loss of property value	S	Legislature considering changes to existing compensation laws. Siting Authority has recommended repeal of state tax, hike in county tax to 6%, etc.
Maine	Impact payments	Payments in lieu of property taxes plus impact payments	No	No	Property value guarantee; details to be negotiated, with host community	S	Impact payments go either to a site community, or, if site is located in an unorganized township, to the State. Maine's action to join a compact with Texas and Vermont will require the payment of compensation to Hudspeth County, Texas

Table 16-1
Summary of Various States' Provisions for Compensation and Impact Payments for LLRW Disposal Facility Siting[1] (continued)

State	Payments to State	Payments to Site Community	Payments to County	Payments to Abutting Community	Payments to Individuals	Authority[2]	Notes
Ohio	No	Proposed payments include payments in lieu of property taxes, infrastructure improvements, independent facility monitoring, extra local government staff to handle increased administrative workload, emergency response, and other compensation/ impact payments as negotiated	No	Proposed payments would result from petition by "affected" communities (which may not be "abutting" communities), and negotiations with state	Proposed property value protection program		Proposals offered by Ohio Blue Ribbon Commission and LLRW Advisory Committee, and submitted to Ohio governor and legislature in September, 1993 to assist them in developing legislation[7]
Penn-sylvania	No	Payments in lieu of property taxes plus $ for local education, emergency response, and inspections, plus unspecified yearly payments, regardless of volumes, plus an amount per unit of waste (to be negotiated by facility operator and site community)	No	No	Guarantee to repurchase property within 2 miles of disposal facility boundary for 2 yrs. after license issuance; payment of school district and municipal property taxes for individuals whose primary residence is within 2 miles of site (for life of facility); at 3-yr. intervals, operator must conduct cancer-related health surveys and offer whole-body radioactivity measurements for all living within 5 miles of facility	S	

Table 16-1
Summary of Various States' Provisions for Compensation and Impact Payments for LLRW Disposal Facility Siting[1]
(continued)

State	Payments to State	Payments to Site Community	Payments to County	Payments to Abutting Community	Payments to Individuals	Authority[2]	Notes
Colorado	1% of annual gross revenues	2% of annual gross revenues, less amount paid in lieu of property taxes[8]	2% of annual gross revenues, less amount paid in lieu of property taxes[8]	No	No	S	
S. Carolina	$4.00 per cubic foot, and various surcharges which now = a portion of $220 per cubic foot	No	2.4% of gross operating revenues but not > than $440,000/yr.	No	Facility operator buys locally, hires locally	S	
Washington	No	No	No	No	No		

[1] This table summarizes "financial" payments for compensation and impact payments. Some states may also provide non-financial compensation.
[2] The basis for providing impact payments and compensation is either statutory -- S or Discretionary -- D.
[3] Some of Connecticut's compensation is statutory; other (i.e., payments under the "volunteer" program), were recommendations approved by the Legislature.
[4] The amounts of compensation and impact payments shown in Illinois refer to the negotiated agreement between the State and the city of Martinsville, Illinois. After the negotiated agreement was reached, the Illinois Siting Commission determined that the Martinsville site did not meet the State's siting criteria, and was therefore dropped from the siting process. Illinois has begun siting again, and is assumed to be willing to negotiate a similar compensation/impact payment package.
[5] These provisions for financial compensation and impact payments apply to LLRW storage, treatment, and disposal facilities sited pursuant to state law, Chapter 111H.
[6] The Low-Level Radioactive Waste Management Board has established a policy of guaranteeing property values within one-half mile (and potentially as far as one mile) from a facility's waste management area. The property value guarantee program would be triggered by the Board's announcement of 2-5 candidate sites to undergo a detailed (year-long) site characterization. Owners of properties within the Property Value Protection District of each candidate site would receive a pledge at that time, that if their candidate site were ultimately chosen as the "superior" site, their properties will be guaranteed at the value that existed at the time of the candidate sites identification announcement. The guarantee would remain for five years after the facility is operational, and be paid by the facility operator if properties are put up for sale.
[7] Ohio was recently designated host state for the Midwest Compact. Ohio's Legislature is currently considering various provisions for compensation and impact payments.
[8] Colorado law provides for a payment to either the host municipality or the host county of 2% of facility operating revenues. The amount cannot exceed 2%, and must be mutually agreed upon by the host governmental entity and the facility licensee.

Source: Larsen, G. "Host State Compensation and Impact payments Summaries." Midwest Interstate Low-Level Radioactive Waste Commission, St. Paul, MN, April, 1989; conversations with various state officials, and review of state laws, 1992 and 1993.

described in Chapter 5.

The first occasion when compensation is part of the siting process occurs when the Management Board makes grants available to communities interested in assessing the economic impacts of a facility, and potentially volunteering a site for consideration. The "economic impacts" grant program, as well as the "volunteer sites" program, are not statutorily mandated by state law. Instead, they are policy decisions made by the Board to enhance the success of the siting process, and to increase public participation. The first statutorily-required provision for compensation as part of the siting process occurs when the Community Supervisory Committees (CSCs) are established after candidate sites are identified, but before the four-season-long detailed study and characterization of the sites begins.[7] The CSCs are local citizens and local officials in each candidate site community, appointed by the chief executive official of the municipality, to ensure that their community's concerns regarding environmental protection, public health, safety, and other issues are well represented during site review activities.

CSCs receive compensation from the Management Board so that they may hire administrative and clerical personnel, and retain consultants for advice on technical matters.

During this period of year-long detailed site characterization, CSCs and citizens in the potential site communities also receive technical assistance from the Management Board. That technical assistance, which will be augmented by the independent technical consultants retained by the CSCs, is crucial to the CSCs' review of all suitable LLRW facility technologies available, since the "Superior Site" CSC ultimately selects the type of facility that best protect's its community's interests.

While a dollar amount cannot be identified for either the CSCs' grants-in-aid or the assistance by the Management Board, the total compensatory funds at this stage of the siting process, to help the candidate site communities independently evaluate the proposed facility site, is expected to be sizeable.

In addition to their review of the site characterization work and data collection, the CSCs are also responsible to interview potential facility operators and negotiate for certain conditions that are important to the potential site community. These conditions could cover such issues as:

- procedures to ensure proper facility operation in order to protect public health, safety, and the environment, and to serve the site (and neighboring) community's interests;
- transportation routing;
- access road construction;
- limitations on the hours or numbers of daily deliveries of LLRW to the facility;
- the number of employees to be hired from the community and surrounds; and
- the amount of business that would be purchased locally.

Once the final site has been selected, after the Management Board reviews all the environmental data from the site characterization studies, the CSC representing the site community will continue to receive financial assistance from the Management Board to fund its continued work of:

- choosing a company to operate the facility;

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[7] Please refer to the discussion of the site selection process in Chapter 2.

- selecting the type of facility technology best suited for the site and the site community; and

- consulting with the Management Board and the operator during negotiations for a comprehensive operating contract.

Funding will continue to be available to the Superior Site CSC for the retention of consultants and advisers.

The Superior Site CSC's role in the negotiations leading to the selection of the facility operator is to ensure that the very best possible package of compensation and impact payments is offered, and then incorporated into the comprehensive operating contract. As can be seen from Table 16-1, there are some explicit statutory provisions for compensation identified in the State's LLRW Management Act, Massachusetts General Laws c.111H (Chapter 111H). However, the law also allows flexibility to the Superior Site CSC and the Management Board for the purpose of enabling the negotiations to produce the specific impact payments and compensation sought by the site community.

The package of impact payments and compensation in the comprehensive operating contract which are summarized in Table 16-1 and are required by law, include:

- the provision that the site community receive property tax payments from the facility operator from the time of the issuance of a facility license through all the years of facility development, operation, closure, post-closure observation and maintenance, and institutional control;[8]

- an annual payment to the site community (and possibly to neighboring communities, depending upon the location of the facility) during facility operation, ranging between $240,000 and $400,000 (or 4% of gross operating revenues), based upon the amount of waste accepted into the facility;

- $150,000 per year from the time the facility begins operations, and ending five years after the issuance of the facility license;

- all agreements the facility operator made during initial negotiations with the CSC; and

- all agreements made by the Management Board for the benefit of the site, affected or neighboring communities,[9] such as obligations to reimburse a community for road maintenance or reconstruction, or other increased infrastructure costs resulting from facility siting, development, or operation.

The precise agreements between the site community and the operator, and the site community and the State, are left to the negotiations process, so that issues most important to the community can be

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[8] State law exempts state property from local property taxation. However, Chapter 111H requires property taxes to be paid once title is acquired by the State. Presumably, the payment of these property taxes would be negotiated between the Commonwealth and the operator. The facility operator is responsible to pay the "in lieu of property tax" payments until the facility license is transferred to the State during the institutional control period, at which time the payments are made by the State.

[9] An "affected" community is one, other than the site community, that is identified in an environmental impact report, which can be expected to experience significant impacts as a result of the location, development, operation, or closure activities at a facility. A "neighboring" community is a community, other than the site community, which, according to the most recent census, has at least 20% of its population residing within three miles of any superior site.

addressed. These may include guarantees to hire locally, or purchase goods and services locally.

One type of compensation, which Chapter 111H allows to be negotiated between the site community, the facility operator, and the State, is a system of property value guarantees. Because the Management Board has adopted a policy of guaranteeing property values within one-half mile (and potentially as far as one mile) from a facility's waste management area, this issue would not need to be negotiated.

The Board's property value guarantee program would be triggered by its announcement of the two to five candidate sites that would undergo detailed (year-long) site characterization. Owners of all properties within the Property Value Protection District of each candidate site would have a "pledge" at the time of the initial announcement of candidate sites, that if their candidate site were ultimately chosen as the superior site, their properties will be "guaranteed" at the assessed value which existed at the time of the Candidate Sites Identification Report announcement. The guarantee would continue for five years after the facility is operational, and be paid by the facility operator if properties within the District are put on the market.

A full discussion of the Management Board's policy on property value guarantees can be found in Chapter 17.

Compensation Provided in Other State Laws

In general, the types of compensation and impact payments offered in Chapter 111H are consistent with compensation policies in other state laws. Some of the laws containing compensation and impact payments provisions include:

- A $1.00 per ton tipping fee (to increase yearly by the percentage increase of the consumer price Index) must be paid to a site community for each ton of solid waste entering a landfill or resource recovery facility. [Massachusetts General Laws c.16, section 24A]

- The Department of Corrections may enter into agreements In connection with prison facility siting. [Massachusetts General Laws c.124, section 10] In addition, one of the Department's bond authorizations created an Infrastructure Grant Program that authorized $15 million dollars to assist communities in financing infrastructure repairs, purchases, replacement or construction necessitated by increased local demands due to the construction or expansion of state and county correctional facilities. [St. 1985, c. 799]

- Another bond authorization provided $6 million to "mitigate Impacts" of the Hampden County jail and House of Correction on the town of Ludlow. [St. 1989, c. 714]

- A provision for "compensation, services and special benefits" provided to the site community by the developer of a hazardous waste facility, and "services and benefits," and property tax payments by State government. The Hazardous Waste Facility Siting Act also provides that compensation may include direct financial payments to the site community to assure the "health, safety, convenience and social and economic security of the host community and its citizens." [Massachusetts General Laws c.21D]

- The Massachusetts Water Resources Authority (MWRA) may enter Into contracts relating to its mission of providing water and sewer service for metropolitan Boston. [Massachusetts General Laws c.92 Appendix, sections 1-5] Under this authority, the MWRA and the Town of Winthrop negotiated an agreement regarding the construction of the secondary wastewater treatment facilities at Deer Island. Included in the agreement was a promise that the MWRA would:

- mitigate transportation impacts from construction workers and equipment traveling through Winthrop (busing, boat transport, etc.);

- install new water main, gas main, and temporary power cable through Winthrop to serve the needs of the new treatment facilities, and to restore roads disturbed by this construction;

- pay for fire services and provide certain fire fighting and rescue equipment, until the MWRA establishes its own fire department on the site;

- provide a job-training program for positions at the treatment plant;

- provide $24 million over 13 years through a grant program that would cover the costs of the above-listed compensation, and provide additional compensation such as the town's legal costs, public works, and other improvements to serve "impacted areas," and rehabilitation of privately-owned properties to reduce noise impacts and promote soundproofing.

The legal agreement between the MWRA and Winthrop states: "By this grant program, the MWRA recognizes that the total impact to the Town cannot be measured nor offset solely by the environmental and compensatory items delineated above. The purpose of this program is to create a public benefit and to mitigate the impact of the facility on the operation of Town Government and on the lives of affected residents by allowing the Town the flexibility to determine, as the project continues, the areas in which mitigation efforts are most needed."

16.5 Recommendations on Community Compensation and Impact Payments

The provisions of Chapter 111H provide a number of opportunities for potential site communities, and the superior site community, to negotiate for compensation and impact payments beyond the lump-sum payments and other compensatory services identified. Therefore, only a few recommendations are offered below:

<u>Impact payments to offset potential risks</u>. The siting of an LLRW storage, treatment, or disposal facility is an important local concern. Impact payments should be offered by a facility operator to offset potential environmental, health, and economic risks.

<u>State should provide economic development funds</u>. State resources used to promote local economic development should be available, if necessary, to augment funds authorized specifically for LLRW management activities.

<u>Volunteer sites should be encouraged; grants to consider siting</u>. If a decision is reached to initiate the Chapter 111H siting process to identify lands within the Commonwealth for an LLRW storage, treatment, or disposal facility, the Management Board should seek to identify communities interested in volunteering to serve as the site community for such a facility. All communities interested in the potential of volunteering realistic sites should receive funds from the Management Board to evaluate the economic impacts of hosting a facility, after the issuance of the Possible Locations Report. This report, one in a series issued by the Management Board during site identification, identifies land areas that are likely to contain one or more candidate sites to undergo further, detailed site characterization.

<u>Property value guarantee program is an important method of compensation</u>. The policies on

property value guarantees contained in Chapter 17 are important compensation provisions.

16.6 Chapter References

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Chapter 17: Ensuring Property Values in the Vicinity of LLRW Storage, Treatment, and Disposal Facilities

17.1 Introduction

When considering whether or not to site a storage, treatment or disposal facility for low-level radioactive waste (LLRW), the public expresses differing views. Some people welcome such activities because of the jobs and economic benefits that would result. Others may be willing to consider facility siting, but have environmental, health, or safety questions they want addressed. Some individuals react with the belief that an LLRW facility is a "locally unwanted land use," or "LULU."

As has been described in Chapter 16, many states provide various forms of compensation and impact payments to offset the real and perceived burdens to a site community, and its residents, of an LLRW site.[1] The concept of protecting property values, which is the subject of this chapter, is emerging as a new type of available compensation.

This chapter reviews academic studies of the impacts on property values of various types of LULUs. Some, like landfills, are not technologically comparable to the LLRW facilities permissible by Massachusetts law. However, very few examinations have been published on property value impacts, and those relating to landfills provide interesting insights into the need for a policy regarding property value protection.

This chapter also describes property value protection mechanisms developed in other states for LLRW disposal facilities. In addition, the chapter includes the recommendations of the Low-Level Radioactive Waste Management Board to protect the value of property in the vicinity of any LLRW facility within Massachusetts, if one for storage, treatment, or disposal were necessary to be sited here.

In making its recommendations, the Management Board does not affirm that property values would decline in the vicinity of any LLRW facilities developed in Massachusetts according to the protective requirements of Massachusetts General Laws c. 111H (Chapter 111H). Instead, based on various studies cited in this chapter, and other research, the Board believes there would be no negative impact on property values as a result of such facilities. The Board supports a property value protection mechanism as a matter of equity and fairness, to ensure that citizens who may live or own property near such a facility are fully protected, if property values were to diminish as a result of facility location.

[1] Chapter 16 describes numerous types of compensation and impact payments, including property value guarantees, that are available to communities and residents where LLRW facilities are sited. In addition, Table 16-1 of Chapter 16 summarizes all the statutory and discretionary provisions for compensation and impact payments which the states that currently operate LLRW disposal sites, or are in the process of developing LLRW sites, are utilizing.

17.2 Perceptions of Unwanted Land Uses

The term "locally unwanted land use," or "LULU," was coined in 1981 by Rutgers University Professor Frank Popper to describe a variety of activities perceived by local residents to be unsightly, noisy, potentially destructive to the environment and public health, or generally degrading to a community. Many of the land use activities of an industrial society fit into someone's definition of such disamenities: landfills, incinerators, prisons, airports, massive roadways, shopping malls, hazardous waste disposal facilities, and housing developments.

A facility for the storage, treatment, or disposal of LLRW could be expected to fall into the "LULU" category. Even though a disposal facility in Massachusetts could not be a landfill because of the state law prohibiting LLRW dumps -- and therefore would not compare at all to closed LLRW landfills around the country which fell victim to environmental problems[2] -- the public is likely to consider a modern LLRW facility as an unwanted land use. Despite the fact that a facility, if necessary to be built in Massachusetts, would have to be designed with the latest "state of the art" technology -- chosen by the site community -- it is likely to be termed a LULU by some.

And along with that assessment, citizens may perceive that an LLRW storage, treatment or disposal facility would adversely affect their residential property values. The extent of the negative impact may depend upon the location of the site, the type of technology proposed, and local attitudes toward LLRW facilities in general.

The use of property value protections, or land value guarantees is a new form of economic compensation to property owners in communities or regions where a LULU is sited. Guarantees of compensation are offered directly to abutting landowners in order to provide protection against perceived or real property value reductions because their property is near a disamenity. Such a guarantee is not a traditional form of local compensation, which customarily has been made as payments to local governments (instead of individuals), including:

(1) Payments In lieu of property taxes. Because the Commonwealth does not pay local real estate taxes on state-owned land, compensation is frequently provided by making payments to the local government in the amounts that the municipality would have received in property taxes, had some non-state activity settled on that site; and

(2) Users fees. Those using a facility often pay a percentage of the user fees as a so-called "tipping fee," which goes into the treasury of the site community.

A surcharge system (number (2) above) is in effect for the disposal of LLRW at the Barnwell, South Carolina commercial disposal site currently used by Massachusetts LLRW generators. Massachusetts generators who have access to this site pay $220 per cubic foot of waste disposed of at Barnwell, in addition to the normal fees charged by the site operator. Prior to imposing the $220 surcharge, Barnwell and the other two disposal sites that were formerly available to Massachusetts,[3] had imposed surcharges of from $20 to $160 dollars per cubic foot in effect ever since these extra fees were authorized under the federal Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPAA).

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[2] Please refer to Chapter 1, Appendix 1A, for a description of certain closed LLRW disposal sites and their accompanying problems.

[3] These facilities are located in Beatty, Nevada, and Hanford, Washington. A description of each is contained in Appendix 1A of Chapter 1.

Economic assistance to a site community or region is an important aspect of facility siting policy. The assistance offsets existing and potential costs and other impacts of a facility on the community, by compensating local government and local residents for assuming a responsibility for the management of LLRW.

17.3 Review of Studies on the Impact of LULUs on Property Values

Studies about property value protection as a mitigating factor for siting waste facilities can be separated into two distinct categories:

(1) studies of the public's perception of living near a LULU; and

(2) studies analyzing the actual effects on property values from their proximity to certain waste facilities. This second category can be further divided into:

(a) evidence that shows no diminution of value, and

(b) evidence that shows property values decline at certain sites.

Studies on Public Perception

The public's perception that property values diminish near waste facilities is clear from several studies conducted over the past decade. A poll sponsored by the U.S. Council on Environmental Quality, the U.S. Environmental Protection Agency (EPA) and other federal agencies, whose results are summarized in Figure 17-A, showed that:

- only about 12% of the public would voluntarily live two miles or less from a nuclear power plant;
- about 15% would voluntarily live two miles or less from a hazardous waste disposal site;
- less than 30% would voluntarily live two miles or less from a coal-fired power plant;
- about 30% would voluntarily live two miles or less from a large factory; and
- about 65% would voluntarily live two miles or less from a 10-story office building.

Another 1980 survey included a series of questionnaires answered by individuals in Wisconsin with knowledge of, or experience in, waste facility siting. The results ranked the perception of property value diminution as the highest of seven economic factors affecting most siting proposals.[4]

This Wisconsin study reflected the feelings of Wisconsin citizens, who, like the public in other parts of the country, expressed their opposition to solid waste facilities by adopting local zoning requirements to prohibit facility siting. As a result, the Wisconsin Legislature established an ad hoc committee to study the siting impasses between the State and local communities. The committee's recommendations became law

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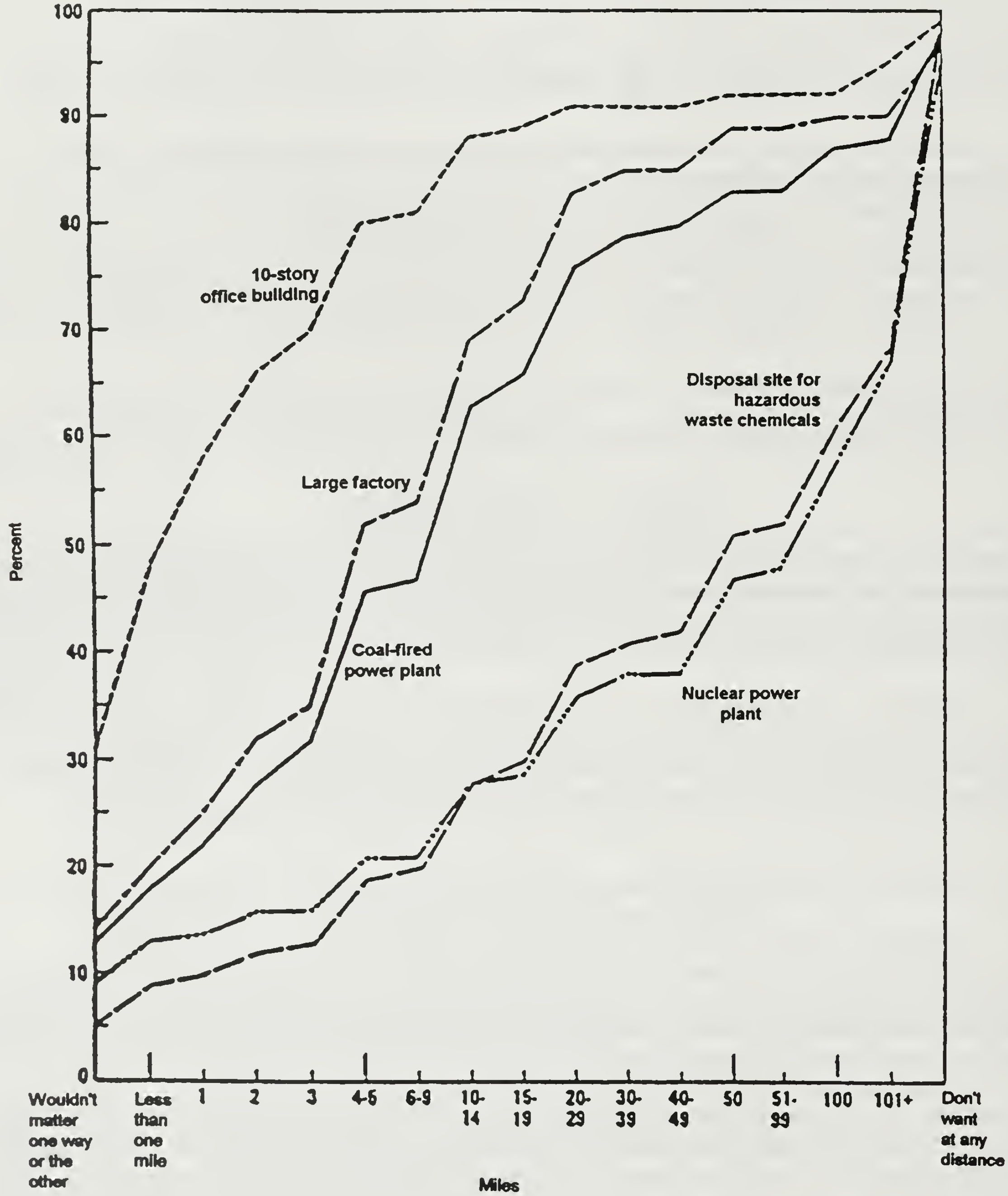
[4] Fish, A.R. and Romano, S.A. A Systemic Approach to Siting Waste Management Facilities. Paper presented to the Third Annual Conference of Applied Research and Practice on Municipal and Industrial Waste, Madison, WI, September 10-12, 1980.

Figure 17-A
Percentages of Public Surveyed Willing to Live Within Various Distances from Certain Industrial Activities



Source: U.S. Council on Environmental Quality, U.S. Department of Agriculture, U.S. Department of Energy, U.S. Environmental Protection Agency. Public Opinion on Environmental Issues: Results of a National Public Opinion Survey. Government Printing Office, Washington, DC, 1980.

in 1981, and mandated the use of negotiation and arbitration to resolve socio-economic concerns at the community level. The negotiations that have occurred under this law have frequently included property value guarantees, and will be discussed further in Section 17.4.

A Pennsylvania study on LLRW policy issues, involving a random survey of Pennsylvania citizens, identified the protection of property values as "extremely important."[5] Those surveyed were asked to assign a level of importance to five different financial incentives:

- Property value protection;
- Agricultural price protection;
- Local tax relief;
- An agreement by the facility operator to purchase and hire locally; and
- A surcharge on each cubic foot of waste for any use chosen by the site community.

As is shown in Table 17-1, all five economic benefits were judged at a level of "extremely important," with property value protection receiving the highest percentage ranking.

Table 17-1
Importance of Economic Benefits in Survey of Pennsylvanians
(In Percentages, N=810)

Economic Benefits	Level of Importance				
	Extremely	Somewhat	Not Too	Not	Missing
Property Value Protection	91	7	1	--	1
Agriculture Price Protection	79	14	2	--	3
Local Tax Relief	43	34	11	9	3
Operator Buy, Hire Locally	58	28	8	3	2
Waste Surcharge to Locals	51	34	8	5	2

Source: Vincenti, J. Opinions of Pennsylvanians on Policy Issues Related to Low-Level Radioactive Waste Disposal. The Pennsylvania State University Institute for Research on Land and Water Resources Public Involvement and Education on Radiation Program, University Park, PA, September, 1985.

Studies Identifying No Property Value Reductions

One category of studies evaluating the actual effects on property values reveals an Interesting result: while the perception is significant that property values would decline, properties do not necessarily lose their value as a result of nearness to an unwanted facility.

[5] Vincenti, J.R. Opinions of Pennsylvanians on Policy Issues Related to Low-Level Radioactive Waste Disposal. The Pennsylvania State University Institute for Research on Land and Water Resources Public Involvement and Education on Radiation Program, University Park, PA, September, 1985.

This conclusion is shown in the results of several property value investigations. A study published by the EPA in 1975 reviewed property values surrounding four California landfills.[6] This study used several variables including selling date, housing characteristics, distances to highways, distances to the landfills, views of the landfills, and angles from prevailing downwind locations in a regression analysis to evaluate sales price and assessed value. In the cases of three of the four landfills, no significant correlation was discovered between the property values and landfill impacts. In the fourth landfill case, a positive correlation of distance and price was found, presumed by the authors to be due to the fact that the landfill was expected to close soon after the date of the study.

The lack of a consistent negative impact on residential property values was also the conclusion of three studies that evaluated the Three Mile Island incident;[7] another that studied various solid waste management facilities including waste-to-energy plants, landfills, and transfer stations;[8] and a fifth that also used a multiple regression equation to evaluate the potential for negative property value impact.[9]

This last study also identified a typical change in use of the land around numerous waste disposal facilities, after they were sited. According to the researchers, most solid and hazardous waste disposal facilities are located in rural communities outside urban centers. However, their studies of 20 such facilities showed that land use at one-half of the sites changed from open space or agricultural to middle-class, suburban, residential use, and development was occurring near 65% of the disposal sites.[10] The authors speculate that rising unit property prices and the increasing density that occurs after siting means that property values increase during new development, which can "more than offset decreases due to facility impacts."

Another academic analysis that reveals contradictory opinions on the question of property value declines was recently conducted by researchers at the University of Tennessee to evaluate the economic and social impacts on Barnwell County of the LLRW disposal site near Barnwell, South Carolina.[11]

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[6] Schmalensee, R. "Measuring External Effects of Solid Waste Management." U.S. Environmental Protection Agency. R.801673. Washington, DC, 1975.

[7] Three studies published following the Three Mile Island nuclear power accident showed no measurable negative impact on property values. These studies include: D.P. Shearer, "Three Mile Island Nuclear Accident Community Impact Study on Real Estate," for the Greater Harrisburg Board of Realtors, March, 1980; J.P. Nelson, "Three Mile Island and Residential Property Values: Empirical Analysis and Policy Implications," in Land Economics, Vol. 57, No. 3, 1981; and H.B. Gamble and R.H. Downing, "Effects of Nuclear Power Plants on Residential Property Values," in the Journal of Regional Science, Vol. 22, No. 4, 1982. In this last study, the researchers point out, however, that the closure of the plant during their study period may have delayed the effect on property values.

[8] Zeiss, C. and J. Atwater, in their published study, "Waste Facility Impacts on Residential Property Values" in the Journal of Urban Planning and Development (American Society of Civil Engineers), Vol. 115. 1989, report on a study by J. Price, whose conclusions were published in the Proceedings of the 25th Annual GRCDA. Saint Paul, MN, 1987.

[9] Zeiss, C. and J. Atwater, Ibid.

[10] Ibid.

[11] English, M.R. and Murray, M.N. The Economic and Social Impacts of Chem-Nuclear's Low-Level Radioactive Waste Disposal Facility on Barnwell County, South Carolina. University of Tennessee, Knoxville, TN, January, 1991.

The Barnwell study included an assessment of the views of the people of Barnwell County regarding the social and economic impacts of the Chem-Nuclear Systems, Inc. LLRW disposal facility. A mailed questionnaire, personal interviews, and a review of newspaper articles in the facility's host county indicated that the majority of Barnwell County residents regard the LLRW disposal facility as "an economic plus for the county, as a good corporate citizen, and as posing no major drawbacks."[12] Some of the survey questions appear in Table 17-2.

Sixty-two percent of the respondents to the mailed survey and the personal interviews indicated that the LLRW disposal facility "has not substantially affected their property values." Of those who said their property values were affected, 26% said the effect was positive due to the disposal facility's presence, 62% said there was "no change" in their property values, and 6% responded that their property values were negatively affected, due to the stigma of the facility's nearby location.

Another Pennsylvania study by social scientists at Pennsylvania State University evaluated the effects of certain sanitary landfills on residential development and property values.[13] No difference was found in the value of residential properties adjacent to the landfills selected for the study than in the study control areas, except for properties on the access roads leading to the landfills.

The researchers suggest this result is due to the fact that demand for residential property means that there were enough people willing to purchase property and not be concerned about the LULU. However, they note that "it may take longer for properties near LULUs to bring the prices anticipated, and this can impose costs on the sellers."[14]

Studies Identifying Losses in Property Values

The other subset of actual property value studies, not just public perceptions, reveals that values do decline in some cases. Summarized below are three such academic studies as well as some observations from the recent proposal by the Massachusetts Water Resources Authority (MWRA) to site a landfill in Walpole, Massachusetts.

G. Blomquist evaluated the impacts on property values around a steam-electric power plant in Winnetka, a wealthy suburb of Chicago.[15] Using a formula that weighed mean property value, average number of rooms per house, distance from the power plant, and racial homogeneity, he concluded that within 11,500 feet of the plant, "a typical property loses 0.9 percent of its value for each 10% move closer to the plant."

A study specifically related to an old commercial operation where radioactive waste was present correlates property value declines not with the presence of the LLRW-contaminated site, but with the fear

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[12] The study points out that it made no attempt to analyze the disposal site's environmental impacts. Concerns expressed through the mailed survey and personal interviews often related to uncertainties about the long-term health effects of the facility after it is closed.

[13] Gamble, H.B. and Downing, R.H. "Effects of Sanitary Landfills on Property Values and Residential Development." From Solid and Liquid Wastes: Management, Methods and Socioeconomic Considerations. Majumdar, S.K. and Miller, E.W.(editors), The Pennsylvania Academy of Science, 1984.

[14] Ibid.

[15] Blomquist, G. "The Effect of Electric Utility Power Plant Location on Area Property Value." Land Economics Vol. 50 (pp. 97-100), February, 1974.

Table 17-2
Selected Survey Questions and Responses (%)
LLRW Disposal Facility in Barnwell County, S. Carolina

Were you aware that Chem-Nuclear has a low-level radioactive waste disposal business in Barnwell County?

Yes	96
No	4

Do you think that, on the whole, Chem-Nuclear has been good for Barnwell County?

Yes	79
Qualified yes	8
No	9
Qualified no	3

Are you concerned that having Chem-Nuclear in Barnwell County may be bad for the health of you, your family, or others?

Yes	21
Qualified yes	6
No	64
Qualified no	7

Do you think that Chem-Nuclear affected your property values?

Yes	29
Qualified yes	3
No	62
Qualified no	2

If it has, have property values gone up or down because of it?

Up	26
Down	6
No change	62

Do you think that Chem-Nuclear is more or less dangerous than the local landfill for garbage?

More	26
Less	56
About same	13

Source: English, M.R. and Murray, M.N. The Economic and Social Impacts of Chem-Nuclear's Low-Level Radioactive Waste Disposal Facility on Barnwell County, South Carolina. University of Tennessee, Knoxville, TN, January, 1991.

of health risks that were initiated by negative publicity about the site.[16]

The study area surrounded the Kerr-McGee Chemical Corporation's "Rare Earths Facility" industrial site in West Chicago, Illinois, a suburb of Chicago, where thorium ore and thorium nitrate were used in the manufacture of gaslight mantles. According to the researchers, the site had been contaminated with LLRW

[16] Payne, B.A., Olshansky, S.J., and Segel, T.E. "The Effects on Property Values of Proximity to a Site Contaminated with Radioactive Waste." Natural Resources Journal. Vol. 27. (pp. 581-590) University of New Mexico School of Law, Albuquerque, NM, 1987.

for over 50 years, but the public was not aware of the contamination until July, 1976, when a local newspaper ran a story about the site. During the development of an environmental impact statement relative to the decommissioning of the Kerr-McGee site, area residents began complaining of losses in their property values.

The researchers reviewed the real estate transactions for single-family homes at two separate distances from the Kerr-McGee facility: an "inner ring" of homes within a two-block radius from the perimeter of the facility, and an "outer ring" of homes located from two blocks to one mile from the site. Both the "listed" price and the "selling" price were evaluated, as well as the year of the sales and the ages of the homes.

Results showed that there were significant differences in home values during the "pre-publicity period" of 1973-1976, but distance from the site did not significantly change the selling price. During the "post-publicity" years of 1977-1982, only the older homes within the two-block inner ring area suffered from property value declines, while newer residences were unaffected by their distance from the site.

The authors of this study make the following observation:

> "... whether the site actually is hazardous is not really important. What is relevant is that it is perceived as such, and it is the perception or fear associated with the facility that becomes translated into observed negative effects on property values."

The third study of interest which substantiates that property value losses can occur in some instances was conducted under a grant provided by the EPA.[17] It, like the Kerr-McGee study, found that perceived risks led to lost property values, even though the perceived risks were greater than the actual risks.

The site studied involved an area around the Operating Industries Inc. municipal landfill located between Montebello and Monterey Park in the suburbs of Los Angeles, California. The landfill operated as a solid waste landfill from 1948 until it closed in 1984. From 1976 until January, 1983, it also accepted hazardous wastes. As a result, it was proposed for inclusion on the National Priorities List for federal "Superfund" cleanup. In 1988, 60 companies that had used the landfill agreed to pay $66 million to mitigate the site.

Residents who moved into homes along the southern edge of the site that were constructed in the mid-1970s complained of odor and health problems. Studies of groundwater quality, school absences, mortality, and increased incidences of cancer and liver disease, were conducted by state and regional health officials, but showed no indications of serious health problems.

Researchers used real estate information as well as the perceived health risks of various neighborhoods surrounding the landfill to evaluate the impacts on property values. They concluded that, like the Kerr-McGee study, regardless of whether health risks were factual, the economic losses suffered were real. They found that following closure of the landfill, the average home value increased by approximately $5,000. They also determined that distance from the landfill did not, on its own, affect property values, but distance and odor contributed to the perception of health risks, which caused diminution in home values.

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[17] McClelland, G.H., Schulze, W.D., and Hurd, B. "The Effect of Risk Beliefs on Property Values: A Case Study of a Hazardous Waste Site." Risk Analysis (The Society for Risk Analysis), Vol. 10, No. 4 (pp. 485-498), New York, NY, 1990.

Walpole Property Value Impacts

While no official "study" has been undertaken of the effect on lands adjacent to a proposed MWRA landfill in Walpole, residents who own property near the site blamed their failure to sell their land for its assessed value on the proposal landfill, not on the national economic recession that was affecting properties there and elsewhere.[18]

The lack of a definitive socio-economic study to ascertain whether the proposed MWRA landfill, the maximum security prison already in operation adjacent to the landfill site, or other factors, such as the general reduction in property values resulting from the recession, is the cause of diminished property values in this Walpole area does not matter to the homeowners and property owners who may be unable to sell their property. Their perception, and that of realtors and potential buyers, is enough to cause financial damage. According to real estate brokers in the Walpole area, median sales prices of homes in Walpole have remained higher than several adjacent towns ever since the MWRA announced its proposed landfill site in 1987. However, they also report that property values in the immediate area of the proposed landfill have dropped.[19]

Impact of These Studies

Every published study available points to the fact that considerable concern is expressed about the loss of value for properties located near an unwanted land use. Even if value is not diminished, as many of the studies indicate, the perception that values will drop should be addressed in negotiations about impact payments to a community hosting an LLRW facility site. Economists, social scientists, and risk assessment academicians generally agree that property value protections should be considered as part of a compensation package.

Government has, historically, subsidized losses caused by the public's underestimation of such risks as flooding and other natural disasters, and the use of such products as lead paint and urea formaldehyde home insulation material. Government has also imposed health and safety standards to reduce risk through the adoption of regulations in numerous areas, from drinking water testing to automobile and airplane standards. The question relating to property value protections is whether government should establish a similar policy to mitigate any losses, or fear of losses, that may be caused by the public's overvaluation of risks.

17.4 Property Value Protection Mechanisms

Property value protection policies are a relatively new type of financial incentive being provided in connection with facility siting. The first major use of this policy began in Wisconsin after the passage in 1981 of amendments to that State's facility siting law for solid and hazardous waste disposal. A Waste Facility Siting Board was created to administer a mandatory negotiation/arbitration process at the municipal level on the local economic, social, and land use impacts of a proposed facility. Many of the agreements that have resulted from negotiation include various property value protections.

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[18] Howley, K. "Landfill plan blamed for slump." The Boston Sunday Globe, South Weekly edition, Boston, MA, July 28, 1991.

[19] Ibid.

Negotiations at the local level in the Wisconsin program occur concurrently with reviews and approvals at the state level relating to site review and licensing decisions.

Wisconsin's law has resulted in the productive siting of 37 solid and hazardous waste landfills, a success level that is highly praised by officials of that state. However, it is interesting to note that, despite a successful siting program, no other states are known to have followed Wisconsin's lead to achieve public acceptance of these types of facilities, until very recently.

The use of property value protections is gaining momentum in connection with LLRW disposal siting. Several states developing LLRW disposal facilities have incorporated property value guarantees into their siting policies, even though they have not extended this concept to the siting of other LULUs such as hazardous waste facilities or prisons.

The reason for differences in siting policies is likely due to the federal mandates regarding LLRW disposal, which are far more stringent than the federal requirements for hazardous waste disposal and non-existent for solid waste, prison, and other types of difficult-to-site facilities. The onerous economic cost of these mandates have forced states to take relatively aggressive actions to site LLRW disposal facilities, and therefore to make more impact payments, like property value guarantees, available as siting incentives. h contrast, federal mandates regarding hazardous waste disposal are less arduous, requiring each state to certify in a "capacity assurance" report that a state will be able to meet its hazardous waste management needs over the next two decades.

Table 17-3 summarizes property value protection policies of states operating and developing LLRW disposal facilities. These policies range from no provisions for property value protection, to explicit statutory requirements for property guarantees. As previously stated, a property value guarantee is just one of several types of compensation and impact payments available to site communities. A summary of total impact payments and compensation provided by all LLRW siting states can be found in Table 16-1 of Chapter 16.

Of the states and compact regions involved in LLRW management activities,[20] four states (Connecticut, Maine, Nebraska, and Pennsylvania) have specific references to property value guarantees in their LLRW management statutes, and five (Illinois, Massachusetts, Michigan, New Jersey, and Vermont) have laws enabling negotiations that could include property value guarantees. Five states (California, New York, North Carolina, Ohio, and Texas) have no statutory provisions allowing property guarantees, either by specific reference or through negotiations, although legislation to allow such a policy is under consideration in New York and North Carolina.

The four explicit statutory property value protection policies in the four states that have them vary in their scope and availability, and apply to differing state/compact configurations. Connecticut is siting a facility for its own waste under the provisions of the Northeast Compact;[21] Maine is in the process of joining a regional compact with Texas and Vermont; Nebraska is the host state for the Central Compact region; and Pennsylvania is developing an LLRW disposal facility for the member states of the Appalachian Compact.

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[20] Maine and Vermont are included in this table because these states have statutes relating to property value guarantees that were passed prior to their successful negotiations to join a regional compact with Texas. They are included here for informational purposes.

[21] The other member state in the Northeast Compact is New Jersey, which is also developing a site for its LLRW. This arrangement for two host states within the Northeast Compact region resulted from the inability of either state to agree to host a disposal site for the other's LLRW.

Table 17-3
Summary of State Policies on Property Value Protection for LLRW Facilities

State	Mechanism Enabling Property Value Protection	Authority[1]	Other Financial Incentives, Compensation[2]
California	None	N	No
Connecticut	Facility operator must guarantee value of all property within 2 miles of facility from time of site selection until 5 years after operations begin	SS	Yes
Illinois	Negotiation may allow	N[3]	Yes
Maine	Property value guarantee with details to be negotiated with site community	SS	Yes
Massachusetts	Negotiation may allow	SN	Yes
Michigan	Negotiation may allow	SN	Yes
Nebraska	Property value guarantee for land within 3.5 miles of site boundary during first 5 years of operation	SS	Yes
Nevada	None	N	Yes
New Jersey	Negotiation may allow	SN	Yes
New York	None[4]	N[5]	No
N. Carolina	None[4]	N	Yes
Ohio	None[6]	N	No
Pennsylvania	Repurchase of any property within 2 miles of facility boundary for 2 years after license issued plus payment of school district and property taxes for individuals whose primary residence is within 2 miles of site for life of facility	SS	Yes
S. Carolina	None	N	Yes
Texas	None	N	Yes
Vermont	Negotiation may allow	SN	Yes
Washington	None	N	Yes

1 Authority to provide property value guarantees is either explicitly specified in statute (SS) or authorized by a statutory provision allowing negotiation (SN). No statutory benefits = (N).
2 Table 16-1 in Chapter 16 summarizes all impact payments and compensation provided in each state.
3 Benefits can be paid, at the discretion of the Illinois Department of Nuclear Safety.
4 Legislation is pending in New York and North Carolina that would allow negotiated property value protections.
5 While New York does not currently have a program for compensating site communities, state law requires that the Legislature adopt such a system.
6 Ohio was recently named host state in the Midwest Interstate Compact region. Legislation enabling Ohio to site a disposal facility, and provide impact payments to the site community, is under consideration by the Ohio Legislature. A Blue Ribbon Commission has recommended that property values be considered as part of compensation.

Source: Conversations with state officials, 1992 and 1993.

Connecticut law requires that the facility operator guarantee property values within two miles of the facility, from the time of site selection until five years after the facility begins to accept waste.

Maine's property value protection law is the most general. It provides such a guarantee, but leaves the details to be negotiated between the siting authority and the site community.

Nebraska's property value statute protects landowners within a larger radius of the proposed facility than do any of the other states. Unlike the two-mile wide property value guarantee area of Connecticut and Pennsylvania, Nebraska law guarantees land values within 3.5 miles of the facility site boundary. However, the Nebraska law is triggered at a later date in the LLRW disposal facility siting process, beginning with facility operation, and ending five years later.

Pennsylvania law requires the developer to purchase any property located within two miles of the disposal boundary line for two years after a license is issued at a value equal to that which existed before site selection. In addition, Pennsylvania law provides another financial protection to neighbors of the facility: it requires the payment of school district and local property taxes for persons whose primary residence is within two miles of the site for the life of the facility, currently planned at 30 years.

Pennsylvania's property value guarantee law is triggered when a license is issued for the development, operation, and closure of a disposal facility, which is perhaps nine months to a year later than Connecticut's guarantee begins, but before that of Nebraska.

Massachusetts Statutes Protecting Property Values

No Massachusetts law explicitly guarantees property values at a level that existed prior to the siting or development of a proposed facility. However, as noted in Chapter 16, several Massachusetts laws have incorporated the policy of providing "compensation" to cover the costs of any necessary public improvements or expenditures associated with a facility, and of offering "impact payments" -- over and above the costs associated with a facility.

While not specifically requiring property value guarantees, two Massachusetts laws, the Hazardous Waste Facility Siting Act (Massachusetts General Laws, Chapter 21D) and the Low-Level Radioactive Waste Management Act (Chapter 111H), include language authorizing negotiations that could include property value guarantees as part of a package of community compensation and impact payments.

The hazardous waste siting law, Chapter 21D, section 12, allows the State, the site community, and the facility developer to negotiate various types of compensation in the "siting agreement." Although the exact amount of compensation is not stated in the statute, compensation can include:

(1) technical assistance grants to Local Assessment Committees to finance their evaluation of a proposed facility;

(2) "compensation, services and special benefits" that will be provided to the site community by the developer;

(3) "services and benefits" to be provided to the site community by agencies of state government;

(4) provisions for payments in lieu of taxes;

(5) compensation to "abutting communities;"[22] and

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[22] Chapter 21D defines an "abutting community" as a city or town contiguous to or touching upon any land of the site community.

(6) compensation may include provisions for direct monetary payments to a site community and to assure the "health, safety, convenience and social and economic security of the host community and its citizens."

While also not mandating an explicit property value guarantee, language in the LLRW management law, Chapter 111H, section 33, authorizes the Commonwealth to negotiate a "comprehensive operating contract" with any facility operator setting forth the "rights and responsibilities of each party with respect to the facility and specifying that site, affected and neighboring communities are third party beneficiaries" to this contract.

In addition, Chapter 111H requires the Management Board to make recommendations in this Management Plan "for regulatory or other actions to ... ensure that the value of property in the vicinity of any facility is maintained." [Chapter 111H, section 12 (b)(2)] The next section of this chapter provides those required recommendations.

17.5 Recommendations to Ensure Property Value Protection

On several occasions, the Management Board considered the concept of property value protection, and evaluated public comments received on this subject. The Board concluded that the uncertainty whether property values near an LLRW storage, treatment, or disposal facility in reality would decline, remain the same, or increase, should not be the prevailing reason to recommend "for" or "against" a property value protection system.

Instead, the Board determined that the "perception" of property value loss is real. Despite the Board's belief that an LLRW facility of the types allowed by Massachusetts law (e.g., monitorable and retrievable[23] for LLRW disposal) would not reduce property values, it developed recommendations in favor of a facility operator-funded property value guarantee program. Its program will ensure that citizens who may live or own property near any LLRW facility developed by the Commonwealth would be fully protected, if property values were to decline as a result of facility location. Its recommendations are designed to ensure equity and fairness in connection with any LLRW siting activity, and to secure public confidence that the State's process of siting, developing, operating, closing, and monitoring an LLRW facility over an extended period of years would be implemented in a manner protective of public health, safety, and the environment.

Management Board property value protection system. The Board therefore recommends instituting a facility operator-funded property value guarantee program if a decision is made to institute storage, treatment, or disposal facility siting within the Commonwealth. The program would provide:

(1) a pledge of property value protection for properties surrounding each candidate site that will undergo detailed site characterization,[24] and

[23] Chapter 13 discusses these requirements for an LLRW disposal facility, that makes it similar to very long-term waste isolation (i.e., storage), rather than disposal.

[24] "Detailed site characterization" is the on-site investigatory and analytical step of the site selection process that is designed to identify the hydrologic, geological, and other environmental conditions of each candidate site over a period of four seasons.

(2) a specific property value guarantee for properties surrounding whichever candidate site is chosen as the "superior site"[25] once the facility receives a license.

This property value pledge and guarantee system includes the following provisions:

(1) As of the date the Management Board votes to accept the Candidate Sites Identification Report, which names candidate sites that the Board believes should undergo detailed site characterization, property owners within a half-mile radius of any waste management area identified within each candidate site will receive a pledge notice from the Board explaining that, if the site were chosen and licensed for the development of a facility, their property will automatically be included within a "Property Value Protection District" surrounding the candidate site. In addition, property owners outside the one-half mile radius but within one mile of any waste management area identified within each candidate site will be eligible to have their property considered for inclusion within the Property Value Protection District, by determination of the Management Board, with the advice of the Community Supervisory Committee of each candidate site (who are locally-chosen to represent the candidate site communities' concerns).

(2) Any property within the Property Value Protection District will have the benefit of a pledge of property value protection, which will operate throughout detailed site characterization. This pledge will help to stabilize property values during this period by assuring property owners that the value of their property will be guaranteed if the site is ultimately selected and a facility is licensed.

(3) Once the superior site has been licensed, the seller of any property identified within the Property Value Protection District of the superior site will be entitled to receive a payment from the facility operator, equal to the lost value the property would have had, but for the location of the facility. The guarantee will cover all properties within the Superior Site's Property Value Protection District that are sold after the adoption of a Candidate Sites Identification Report, and will extend until five years after the facility is licensed.

(4) A seller seeking compensation for lost value of real property will be required to submit a request for compensation to the Board, and include in his request a number of documents:

- a copy of a purchase and sale agreement executed after the date of the Board's adoption of the Candidate Sites Identification Report;

- a copy of the deed conveying title, as well as other documentation that the deed has been recorded at the Registry of Deeds;

- an appraisal by a person qualified and authorized to do so, of the actual value of the property as of the date of execution of the purchase and sale agreement; and

- an appraisal by a person qualified and authorized to do so of the value the property would have, but for the facility or the possibility of the facility being sited in that location.

(5) The facility operator will pay the seller an amount equal to the difference in the value such property would have, as of the execution of the purchase and sale agreement submitted to the Board, but for the facility's location or the possibility of a facility, and the actual value of the

[25] A "superior site" is any site selected by the Management Board, after detailed site characterization.

property as of the date of execution of the purchase and sale agreement. The amount to be paid the seller will be determined by the Management Board, after it receives comments from the facility operator.

(6) Only record owners of properties at the time of the adoption by the Management Board of the Candidate Sites Identification Report will be eligible to receive property value pledges and guarantees, not persons acquiring any of the affected properties after that time.

(7) Property owners within the Property Value Protection District will be guaranteed no loss in property value in return for granting the facility operator or the State the right of first refusal for any valid offer received on the property.

The pledge and the guarantee will provide relief only from specifically local adverse market conditions, as such market conditions differ from regional or national conditions. For example, the guarantee will not provide relief from natural disasters or acts of God, or from depreciation due to the failure of real estate owners to maintain their property.

Property value guarantee will be part of comprehensive operating contract. This operator-funded property value guarantee system will be delineated in the "comprehensive operating contract" -- a legally-binding document signed by the facility operator and the State. Chapter 111H includes explicit provisions for compensation to site, affected, and neighboring communities and negotiations with these communities.[26] The subjects for negotiation are not precisely defined in the law, in order for the communities impacted by facility siting to have the flexibility to negotiate conditions that best serve their needs. Details of the possibilities for compensation and impact payments are described in Chapter 16.

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[26] A "site community" is defined in Chapter 111H as a community in which is located all or any part of any "superior" or final site, selected by the Management Board. A "neighboring community" is a municipality other than a site community, which according to the census has at least 20% of its population residing within three miles of any superior site. An "affected community" is a municipality other than a site community which is identified in an environmental impact report as expected to experience "significant impacts" as a result of the location, development, operation, closure, or institutional control of a facility. The discussions on the local role in public participation (Chapter 5) and the local government role in LLRW management (Chapter 2) should be consulted.

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Chapter 18: Liability and Financial Responsibility for LLRW Management Facilities

18.1 Introduction

The obligation assigned by the federal Low-Level Radioactive Waste Policy Act of 1980 to each of the 50 states to be responsible for the management and disposal of low-level radioactive waste (LLRW) carries with it an equally important duty to ensure that insurance is available to protect the public, the State (for example, as owner of the land on which the facility is located), the facility operator, LLRW generators, and LLRW shippers, in the case of any occurrence that may arise involving claims of personal injury and property damage.

This chapter assesses the availability and adequacy of insurance protection for LLRW storage, treatment, and disposal facilities that may be sited, built, operated, closed, and monitored during institutional control[1] in accordance with Massachusetts General Laws c.111H (Chapter 111H), the State's Low-Level Radioactive Waste Management Act.

This chapter also summarizes the development of nuclear liability insurance programs. It reviews the rules of liability and financial responsibility concerning LLRW management activities in Massachusetts, and summarizes liability laws in states that are developing LLRW disposal facilities. In addition, this chapter assesses the types of insurance available from the private market, and the insurance needs of particular parties involved in LLRW activities related to state-supported storage, treatment, and disposal facilities, and LLRW transportation. Recommendations are offered for financial mechanisms that ensure the adequacy of funding for site cleanup and payment of claims from personal injury and property damage.

18.2 The Evolution of Nuclear Liability Insurance

Until 1954, only agencies of the federal government were permitted to use radioactive materials. The U.S. Atomic Energy Act of 1954 authorized the non-government (i.e., commercial) use of these materials, and created the Atomic Energy Commission (now the U.S. Nuclear Regulatory Commission -- NRC) to regulate their use in order to protect the health and safety of the public.

Because no one but the federal government had been using radioactive materials before 1954, there had been no need for insurance companies to provide insurance for the commercial use of radioactive materials. The insurance industry could provide coverage under its general property and liability insurance programs for the uses of radioactive materials by universities, hospitals, medical research companies,

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[1] "Institutional control" is the phase in the life of a storage, treatment, or disposal facility, following closure and transfer of the facility license from the operator to the Low-Level Radioactive Waste Management Board, when the facility undergoes continued observation, monitoring and facility care.

manufacturing firms, and other non-federal uses of radioactive materials.[2] However, the insurance industry was unwilling to provide coverage in the event of a catastrophic nuclear accident at one or more of the nuclear-powered utility plants that were being developed at that time.

Two responses occurred to resolve this problem. The first was action by the insurance industry in 1957 to organize two insurance "pools," voluntarily combining their financial resources to offer the large limits that Congress, the utilities, and the public demanded. These pools, the American Nuclear Insurers and the Mutual Atomic Energy Liability Underwriters, offered $60 million dollar limits of liability insurance.[3]

The second response was the passage by Congress in 1957 of an amendment to the Atomic Energy Act which created a federal government-backed financial protection mechanism of up to $500 million dollars in excess of the $60 million of the insurance pools. The amendment, known at the Price-Anderson Act, limited liability for catastrophic harms to the $560 million dollar total of the two programs with the understanding that, if there ever arose a need to cover losses greater than the $560 million, Congress would have to take appropriate action.

The Price-Anderson Act was amended by Congress in 1975 to begin a phase-out of the federal government's role in providing security against potential future liability. The amendments required that every nuclear-powered utility company would be assessed by the insurance pools up to $5 million per reactor for its share of any loss, in the event an accident exceeded the insurance available from the pool. Thus, once there were 100 operating reactors nationwide, the federal financial protection was phased out entirely.

The Price-Anderson Act was reauthorized in 1988 for another 15 years. The reauthorization increased each nuclear reactor company's assessment from $5 to $66.15 million per reactor, per nuclear accident. The total amount of financial protection from this layer, therefore, now exceeds $7 billion dollars.

The Price-Anderson Act is described in greater detail in Appendix 18A of this chapter.

18.3 General Rules of Liability and Financial Responsibility

Any discussion of financial responsibility mechanisms must begin by making distinctions between two types of losses or harms that may result from LLRW management activities, "first party" losses and "third party" losses. First party losses are harms that occur to property owned by an insured. In the case of an LLRW facility, damage to facility buildings and structures would certainly be classified as a first party loss, and damage to the land upon which the facility is located might also be considered first party, depending on how a particular insurance policy is interpreted.

In contrast, third party losses are those that are suffered by persons other than the insured, and might include personal injury or property damage, perhaps including (again, depending on how a particular insurance policy is interpreted) damage to a facility site.

Financial responsibility for first party losses is generally established by means of insurance programs (or their equivalent) that specify by contract the circumstances under which an insurer will reimburse the

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[2] "Property insurance" provides coverage for damage to property, such as buildings, equipment, etc. "Liability insurance" provides protection against injury or property damage which may occur to others, known as "third party" liability.

[3] Today, this "layer" of insurance protection to nuclear power plants is $200 million dollars.

insured if a loss should occur. Such insurance typically is written so that legal responsibility for the loss is irrelevant. For example, a fire insurance policy will generally reimburse an insured for fire damage even if the fire was caused by the insured's own negligence.[4]

Financial responsibility for third party losses, in contrast, is generally established first by the specifics of federal and state liability rules and second by the terms of any contract providing insurance against third party liabilities under those rules. Liability rules may be established by federal or state statute, or by court interpretations developed on a case-by-case basis over time (known as "common law").

Both the federal government and Massachusetts are protected by a rule of "sovereign immunity" which exempts those levels of government (Massachusetts sovereign immunity extends to local governments as well) from "tort"[5] liability for harms, except to the extent that these governments have agreed to be liable for those harms. The Federal Tort Claims Act and the Massachusetts Tort Claims Act, Massachusetts General Laws c.258, both waive sovereign immunity under certain circumstances. Generally, immunity is retained for "discretionary" or policy-making decisions made by government officials, while it is waived for ordinary negligence, or wrongful acts or omissions, that occur during other types of activities by government workers.

For example, if the U.S. Postal Service were to adopt new postal routes and inadvertently left off a particluar street, so that businesses along that street were damaged by the loss of service, sovereign immunity would protect the Postal Service from liability. On the other hand, if a Postal Service truck caused a motor vehicle accident resulting in personal injury, immunity would be waived.

The Massachusetts Tort Claims Act limits the waiver of sovereign immunity to $100,000. In most circumstances, the Commonwealth is immune from liability for personal injury or property damage in excess of that amount, even if it has caused harms greater than $100,000.[6] Federal law has no similar limitation.

Some federal and state environmental statutes establish special rules of financial responsibility for environmental damage. For example, under the federal Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), which was amended by the Superfund Amendments and Reauthorization Act (SARA) liability to the federal government is established upon proof that:

(1) the site is a "facility;"

(2) there was a release or threatened release of a hazardous substance;

(3) the government has incurred "costs" in response to the release or threat of release; and

(4) the defendant is a "person."

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[4] An exception might arise if the insured was in violation of contract conditions written into the insurance policy.

[5] A "tort" is a wrongful act, not including breach of contract or trust, which results in injury to another's person, property, reputation, or the like, and for which the injured party is entitled to compensation.

[6] However, section 9(c) of Chapter 111H removes that limitation in the case of liability for harm to persons, land, or property that results from the negligence of a state employee for which the Board would otherwise be liable under Chapter 258, and imposes strict liability on the Board for harms resulting from the institutional control of a facility.

Although it is not specifically provided for in the statute, the courts have construed CERCLA as imposing strict liability on responsible parties for the cost of cleanup as well as for damages to third parties caused by certain releases of hazardous materials into the environment at such sites. Unless the defendant (i.e., the entity against whom a claim or charge is brought) can prove that it is responsible for only part of a divisible harm caused at a site, CERCLA also permits, but does not require, the imposition of joint and several liability. The federal Resource Conservation and Recovery Act authorizes EPA to establish liability insurance coverage and other financial responsibility requirements for the licensing of hazardous waste storage, treatment, and disposal facilities. (The corresponding state statutes, Massachusetts General Laws chapters 21E and 21C respectively, contain similar provisions.)

In United States v. Stringfellow, the State of California was found liable to the federal government for the cost of cleaning up a hazardous waste site under CERCLA[7] California was found liable because its activities went beyond mere regulation; it participated in the design and selection of the site, controlled dumping at the site, and participated in the closure of the site. Because of its extensive involvement at the site, the Court held that the State was strictly liable as a site operator, generator, and owner.

As far-reaching as the Stringfellow case may appear, it does not stand for the proposition that nay involvement by the State, (or in the case of Massachusetts, a site community) with a facility at which there is a release of hazardous materials, necessarily results in the imposition of strict liability. Indeed, the court identified 11 "indicia" to consider in deciding whether to impose strict liability"

(1) expertise and knowledge of dangers of hazardous waste;

(2) conception of idea of the site;

(3) design of the site;

(4) supervision, inspection, receipt of reports of the site;

(5) hiring and approving hiring of employees;

(6) determining operational responsibilities;

(7) control of disposal;

(8) ability to discover and abate harm;

(9) public declarations of responsibility;

(10) participation in opening and closing of site; and

(11) benefiting from the existence of the site.

Of these, many would be applicable to the Commonwealth if the Board chooses to develop an LLRW facility, but very few would apply to a site community, merely by reason of its selection of a facility operator and technology from any of those certified by the Board. Therefore, applying the principle of Stringfellow to a

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[7] United States v. Stringfellow, 31 ERC 1315 (1990). Sovereign immunity does not shield a state from CERCLA liability as the Supreme Court has held that "the language of CERCLA as amended by SARA clearly evinces an intent to hold States liable in damages in federal court." Pennsylvania v. Union Gas Co., 109 St. CT.2273,2280 (1989).

Massachusetts LLRW facility from which there is a release of hazardous materials might result in a finding of liability by the Commonwealth (obviously, depending upon the circumstances), but would be unlikely to result in the imposition of liability on a site community.

Common Law Liability

Common law rules that may generally be applied to govern third party liability claims include "strict liability," "trespass," "nuisance," and "negligence." Under the rules of "strict liability," the defendant can be liable even if it was not at fault in causing the harm. In contrast, the doctrines of trespass, nuisance and negligence provide for damages in the case of some form of misconduct or fault on the part of the defendant. In all liability claims, however, the party bringing a suit (i.e., the "plaintiff") must prove that the defendant's conduct caused the injury.

The Price-Anderson Act amendments to the Atomic Energy Act establish a statutory form of strict liability for certain types of nuclear disasters known as "extraordinary nuclear occurrences," for damages up to $560 million dollars. An extraordinary nuclear occurrence is defined in the Act as "any event causing a discharge or dispersal of source, special nuclear, or byproduct material from its intended place of confinement in amounts offsite, or causing radiation levels offsite, which the Nuclear Regulatory Commission or the Secretary of Energy, as appropriate, determines has resulted or will probably result in substantial damages to persons offsite or property offsite." However, in the absence of such an occurrence, the Act is silent as to civil liability for lesser types of mishaps. Accordingly, in Silkwood v. Kerr McGee Corp., the courts have looked to the law of the state where the injury occurred to determine the issue of liability for such accidents. In such cases, federal regulations do not foreclose the application of strict liability, and the courts may apply strict liability rules if the relevant state law so provides.[8]

According to Prosser and Keeton on Torts, Fifth Edition (1984), the courts appear uniformly to agree that private entities involved in the production, transportation, and use of nuclear materials are engaged in activities that are "abnormally dangerous," and are therefore subject to strict liability. As noted, under the rules of "strict liability," the defendant can be liable even if it was not at fault in causing the harm. For example, noting the nuclear industry's unique suitability for the application of strict liability, the Missouri Court of Appeals in Bennett v. Mallinckrodt, has stated, "the value of the nuclear industry to society may be great, but the use of nuclear materials is not yet so common that strict liability should not be applied at this time."

In addition to strict liability, and in the absence of federal and state statutes creating private causes of action, the courts have applied other common law tort principles to remedy harm caused by radioactive emissions, including negligence, nuisance and trespass doctrines.

"Negligence" is generally defined as a breach of a person's duty to exercise reasonable care in all activities. Under negligence principles, the defendant will be held liable only if its conduct, "falls below the standard established by law for the protection of others against unreasonable risk of harm"[9] and constitutes both an actual and a proximate cause of plaintiff's harm. There are four basic elements to a finding of negligence:

(1) The defendant must have a legally-recognized duty to conform to a definite standard of

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[8] See McKay v. United States, 703F.2d 464,468 (10th Cir. 1983). However the caveat remains that a state tort law of strict liability is preempted where it encroaches upon federal regulations setting safety standards. 703 F.2d at 469. See also Silkwood, supra, 667 F2d at 921.

[9] Restatement (Second) of Torts 282.

conduct in order to protect others against unreasonable risk;

(2) The defendant must violate that responsibility;

(3) There must be a reasonably close causal connection between the conduct and the resulting injury, frequently called "proximate cause;" and

(4) Actual loss or damage must result to another party.[10]

Negligence focuses on the defendant's conduct and is therefore difficult to prove in environmental tort cases. This, combined with the availability of many affirmative defenses in a negligence action, has led many plaintiffs to use other common law theories.

The unreasonable, unusual, or unnatural use of one's property, such that the right of others to enjoy their property peacefully is substantially impaired, constitutes a private nuisance.[11] A private nuisance action must include physical damage to the land, to tangibles on the land, or to persons who own or occupy the land. It can be used to recover damages for ground or surface water pollution, solid contamination, damage to riparian rights, and personal injuries caused by exposure to toxic gases, foul odors, or airborne particulate matter.

Public nuisance involves the unreasonable interference with a right common to the general public, such as the pollution of a public drinking water supply, as determined in the Massachusetts case, Anderson v. W.R. Grace & Co.

Finally, an intrusion by radioactive emissions constitutes a trespass where there is proof of actual interference with the plaintiff's right of exclusive possession.[12] Unlike private nuisance action, where a plaintiff will only be compensated upon proof of actual harm, the plaintiff in a trespass action need not prove actual harm, and liability will attach from an intentional invasion on a landowner's possessory interest in real property.[13]

Any of the common law rules of liability outlined above are available to a person seeking compensation from harm caused by radioactive releases. However, because of its relatively easy proof requirements, the use of strict liability principles are to be expected to predominate in the future.

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[10] The reference comes from Prosser and Keeton on the Law of Torts, 5th Edition, 1984, and is quoted in Baird, R., et al. Integrated Evaluation of Financial Assurance Needs for LLW Disposal Facilities. RAE-9006/1-2, Revised Draft. Salt Lake City, UT: Rogers and Associates Engineering Corporation, 1991.

[11] Maryland Heights Leasing v. Mallinckrodt, Inc., supra, where the court held defendant liable for allowing emission of radiation and unreasonably and substantially interfering the appellants' use and enjoyment of their property. The Massachusetts Supreme Judicial Court appears to have adopted the view that private and public nuisances, the latter involving the unreasonable interference with a right common to the general public, are governed by similar standards. See Stop & Shop Cos. v. Fisher, 387 Mass. 889,891 n.2 (1983).

[12] See Maryland Heights Leasing v. Mallinckrodt, Inc., supra, where the court broadly construed the appellants allegation of "physical invasion," concluding that radioactive material deposited on property was sufficient to state a claim in trespass.

[13] See U.S. v. Allied Chemical Corp., and Restatement (Second) of Torts.

18.4 Liability and Financial Responsibility Rules for LLRW Facilities

The rules of liability and financial responsibility governing claims arising from LLRW management activities may affect the number and size of potential damage claims and, in turn, the adequacy of available insurance.

Financial Responsibility for On-Site Damage

Because of the potentially long life of an LLRW facility, especially those for disposal, Chapter 111H explicitly incorporated comprehensive provisions establishing responsibility for facility maintenance and remediation of on-site damage. Chapter 111H also sought to provide adequate financial assurance mechanisms and clear lines of responsibility in order to protect the public and the environment from any potential hazards associated with LLRW.

During facility construction, operation, closure and post-closure, the facility operator is responsible for maintaining the facility's integrity. Any necessary cleanup or restoration of the facility (including on-site buffer areas) during these phases must be completed by the operator.

Under Section 9(a) of Chapter 111H, it is the responsibility of the operator to take all necessary steps to clean up and stabilize the facility and contain migration of radioactive or toxic materials whenever there has been, or might be, a release of such materials at the facility during its operation, closure or post-closure observation and maintenance.[14] The operator must collect user fees in accordance with a schedule approved by the Management Board, adequate to ensure that sufficient funds are available to satisfy this responsibility. However, in the event of a major catastrophe on site, for which all funds, including federal assistance, are exhausted, the Commonwealth will provide the necessary funding for clean-up and restoration.

The Rule of Strict Liability for Personal Injury and Damage to Property

By the enactment of Chapter 111H, section 9(b), Massachusetts has codified for LLRW the common law trend of the state courts to impose strict liability for activities that cause environmental harm. That section provides that any person who transports, treats, stores, disposes, or otherwise manages LLRW will be held strictly liable for any harm to the person, land, or property of another caused by the release of LLRW or associated toxic materials resulting from such an activity.[15] Section 9 (d) further requires that the funds to satisfy third party claims against a facility operator for such harms must be at least the maximum amount available from the nuclear insurance pools or other commercial insurers. Additionally, a contingent liability trust account is established in section 41 of Chapter 111H to compensate for third party injuries if all other funds, insurance, and tort compensation have been exhausted. This requirement of multiple layers of

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[14] The Management Board is responsible for such facility cleanup and stabilization during institutional control.

[15] During the institutional control period, the liability of the operator terminates, unless it has fraudulently concealed information about the facility. During this time, the Management Board assumes the operator's responsibilities for third party claims and is also financially responsible for harm to persons, land, or property resulting from the negligence of its employees during institutional control. Funds available to the operator and, during institutional control, to the Management Board, to satisfy third party claims must be equal to the maximum amount available through commercial insurers. The Management Board accepts the transfer of the facility license, and therefore the responsibilities over third party claims, only after making a determination that the facility is free of problems.

financial protection is intended to provide the greatest possible assurance that any injured parties will be compensated fairly, and that no voids will exist in liability coverage.

In order to recover damages under section 9(b), a plaintiff must show:

(1) that there was a release or exposure;

(2) that the release caused the harm; and

(3) that the plaintiff suffered bodily injury or property damage.

Since the statute imposes a rule of strict liability, the plaintiff need not prove negligence or intent, but only that the defendant's activity caused the harm. Chapter 111H, section 9(b) provides:

> "[A]ny person who carries on any activity involving the management of low-level radioactive waste shall be subject to strict liability for harm to persons, land or property resulting from such activity when caused by any release of, or exposure to, such waste or associated toxic materials...."

Chapter 111H also provides for "joint and several liability," which allows a plaintiff to recover from one or more defendants who may have contributed to the harm, either separately or together. Under this rule, in the absence of other identifiable responsible parties, a defendant may have to pay all damages suffered by the plaintiff, even though that defendant actually caused only a portion of the harm. The Massachusetts statute does, however, eliminate joint and several liability if a defendant can prove that only a portion of the harm resulted from its activities.

The chief obstacle to recovery under section 9(b) is the burden of proving causation. Since there have, as yet, been no cases under this section, the exact nature of a plaintiff's causation burden has not been tested. However, Massachusetts courts may well use standards similar to those applied in cases involving strict liability claims under Massachusetts General Laws c.21E (Chapter 21E), the State's "Superfund" cleanup law, for harm caused by hazardous waste contamination.

In Dedham Water Co. v. Cumberland Farms, Inc., the court analyzed a plaintiff's burden of proving causation when seeking damages under CERCLA, and Chapter 21E for the costs of responding to hazardous waste contamination:

> "In a "one-site" case, involving clean-up of the location where a release occurred, a plaintiff need only show that the defendant's waste was delivered to the site. It is then presumed that the defendant's waste caused the contamination of the site." [689 F. Supp. at 1225-1226]

The defendant may attempt to rebut that presumption by showing that its waste was not the cause of the contamination. [689 F. Supp. at 1225] Presumably, the same standard would apply in the event of a "one-site" strict liability claim under Chapter 111H.

The court in Dedham Water Co. also analyzed a plaintiff's burden of proving causation when seeking damages under CERCLA and Chapter 21E for the costs of responding to hazardous waste contamination in a "two-site" case:

> "In a "two-site" case, in which a plaintiff seeks to recover the costs of cleaning up one site as a result of the release of hazardous waste at a different site, the plaintiff must prove that

the defendant's releases caused the plaintiff's harm. [689 Federal Supplement at 1226[16]]

Again, this standard would likely apply in the event of a "two-site" strict liability claim under Chapter 111H.[17]

Liability of the Commonwealth

In enacting Chapter 111H, the State waived its sovereign immunity from certain tort claims beyond the partial waiver of immunity contained in the Massachusetts Tort Claims Act. Traditionally, the government is immune from all tort claims. The Tort Claims Act allows victims to sue public employers for the negligent acts of public employees acting within the scope of their employment, but limits liability to $100,000 for each claimant.[18] Public employees acting within the scope of their employment are immune from personal liability for their negligent acts.

The Tort Claims Act does not cover intentional torts, for which the government retains its immunity and public employees retain their liability. The waiver of sovereign immunity also does not extend to strict liability claims, pursuant to sections 2 and 10 of the Act.

Under Chapter 111H, section 9(c), the Management Board, community supervisory committees, the Department of Public Health (DPH), the Department of Environmental Protection (DEP) and the Deputy Commissioner of the Division of Capital Planning and Operations (all of whom are "public employers" under the Tort Claims Act) can be held liable for the negligent acts of employees acting within the scope of their employment. Section 9(c) of Chapter 111H provides, however, that there is no $100,000 liability limit for claims against these employees which arise out of LLRW management activities.

Laws in other states in which LLRW disposal facilities are currently operated or are in the pre-development stages vary from that of Massachusetts. Unlike Chapter 111H, the liability provisions are brief and inexplicit in several states' LLRW management laws.

One exception is the State of Pennsylvania. Pennsylvania's liability statute, which is dramatically different from that of Massachusetts and other states, imposes a "rebuttable presumption" of causation, which states:

> (a) Liability of operator. -- It shall be presumed as a rebuttable presumption of law that the operator of a regional facility is liable and responsible for all damages and radioactive contamination within three miles of the boundary of the regional facility without proof of fault, negligence or causation.

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[16] On appeal, the First Circuit Court of Appeals clarified that, neither CERCLA nor Chapter 21E, sections 4-5, requires a plaintiff to prove that any waste physically contaminated plaintiff's property, but only that "the release or threatened release of a hazardous substance from the defendant's property caused the plaintiff to incur reasonable response costs."

[17] Note, however, that Chapter 21E, §5(a) provides for strict liability for damage to property "incurred or suffered as a result of [a] release or threat of release." Chapter 111H, section 9(b) provides for strict liability for harm "caused by any release of...such waste..." Accordingly, a Chapter 111H plaintiff must prove that the harm was caused by an <u>actual</u> release, not a mere threat of release.

[18] The Act also specifies certain procedures for making a claim. In particular, a claim against a public employer must be presented to the employer's executive officer within two years after the case of action arises.

(b) Defenses. -- In order to rebut the presumption of liability, the operator must affirmatively prove by clear and convincing evidence that the operator did not contribute to the damage, or, in the case of radioactive contamination, one of the following three defenses:

(1) The radioactive contamination existed prior to any disposal operations on the site as determined by a pre-operational survey.

(2) The landowner has refused to allow the operator access to conduct a pre-operational survey.

(3) The radioactive contamination occurred as a result of some cause other than regional facility operations.

Under Dedham Water, a plaintiff must still prove that waste from a particular site caused the harm. In Pennsylvania, a plaintiff need only prove that there was an injury due to radiological harm which occurred within three miles of an LLRW facility. American Nuclear Insurers (ANI), the pool of insurance companies that insures the Barnwell, South Carolina, and Hanford, Washington LLRW facilities, currently refuses to write policies for LLRW facilities in Pennsylvania, because of its rebuttable presumption of causation.[19]

18.5 Availability of Insurance

The types of insurance available from the private insurance market depend upon the varying needs of the entities involved in LLRW management.

First Party Insurance

First party insurance is coverage where the insurer agrees to reimburse the insured for losses suffered as a result of specified perils. For example, LLRW shippers carry first party insurance to cover damage to vehicles and equipment. LLRW generators hold first party insurance policies to protect themselves in connection with their on-site use, storage, and treatment of radioactive materials.

Most states with existing or planned LLRW facilities have no regulations requiring their operators to obtain first party insurance for on-site property damage. Facility operators typically either self-insure for on-site property damage or purchase all-risk property insurance, which covers the buildings and equipment located at a facility site, but not the site itself.

Pennsylvania's contract with Chem-Nuclear Systems, Inc. (executed as of August, 1990) does, however, require that Chem-Nuclear purchase all-risk property insurance for the replacement cost of the facility. The amount required is estimated at $60 million by Pennsylvania and over $100 million by the facility operator.

All-risk property insurance is a standard form of insurance readily available from the private market. As noted, however, "all-risk" policies (despite their name) do not cover damage to the land upon which a facility is located. In addition, ANI does not offer a property insurance policy for LLRW facilities that would cover site damage caused by nuclear contamination.

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[19] Quatrocchi, J. "Liability Insurance for Low Level Radioactive Waste Disposal: An Underwriter's Perspective" (Paper presented at U.S. Council on Energy Awareness conference on Nuclear Insurance). New Orleans, LA, Jan. 22-23, 1989.

Third Party Insurance

Third party insurance covers liability to others for harms caused by the insured. A web of insurance policies is available to protect parties in the LLRW cycle against claims by third parties for bodily injury or off-site property damage. Availability of each type of insurance will depend, in part, on an assessment of the risk to be insured. In turn, the risk will vary according to the particular design, location, and operating procedures of the insured activity.

(1) Comprehensive General Liability (CGL) Insurance. CGL policies are readily available and cover most instances of third party liability. CGL policies traditionally contained language purporting to **exclude** coverage for harm caused by intentional or gradual pollution but to **include** coverage (as an exception to the "pollution exclusion") for harm caused by "sudden and accidental" release of pollutants. The standard pollution exclusion clause read:

> "This insurance does not apply...to bodily injury or property damage arising out of the discharge, dispersal, release or escape of smoke, vapors, soot, fumes, acids, alkalis, toxic chemicals, liquids or gases, waste materials or other irritants, contaminants or pollutants into or upon land, the atmosphere or any water course or body of water; but this exclusion does not apply if such discharge, dispersal, release or escape is sudden and accidental."[20]

Many courts across the country have found this traditional "pollution exclusion" language to be ambiguous, and have therefore interpreted the clause in favor of coverage. These courts have taken the word "sudden" to mean "unexpected" and "unintended," so that a discharge of pollutants need not be abrupt in order to trigger insurance coverage.[21]

Two developments have led to a stronger pollution exclusion clause, however, and therefore a greater need for alternative mechanisms for handling pollution liability claims. First, the Massachusetts Supreme Judicial Court recently issued its first opinion on the interpretation of the pollution exclusion clause. In Lumbermans Mutual Casualty Co. v. Belleville Industries, Inc., the court held that "the abruptness of the commencement of the release or discharge of the pollutant is the crucial element" in determining whether coverage is barred by the pollution exclusion clause. Accordingly, CGL coverage of a pollution claim, in a case governed by Massachusetts law, likely will now be found only when there was an abrupt release of pollutants.

Second, the insurance industry has rewritten the standard pollution exclusion clause, eliminating the term "sudden and accidental" therefrom, and excluding coverage of claims relating to bodily injury or property damage arising out of the actual, or alleged or threatened, discharge, dispersal, release or escape of pollutants:

(a) at or from premises owned, rented or occupied by the named insured:

(b) at or from any site or location used by or for the named insured or others for the handling,

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[20] N. Ballard and Manus, P. "Clearing Muddy Waters: Anatomy of the Comprehensive General Liability Pollution Exclusion." Cornell Law Review. Cornell University, Ithaca, NY, 1990.

[21] See, for example, Massachusetts Court of Appeals. Shapiro v. Public Service Mutual Insurance Company. 19 Massachusetts Appeals Court Reporter 648, 650-652, (1985) and cases cited.

storage, disposal, processing, or treatment of waste.[22]

Other versions of the rewritten clause do not cover claims arising from any discharge of pollutants, sudden or non-sudden. While some actors in the LLRW management cycle may still have CGL policies with the old pollution exclusion clause, most will have to purchase separate insurance policies or make some other provision for covering pollution liability.

(2) Environmental Impairment Liability (EIL) Insurance. EIL policies are designed to cover both sudden and non-sudden harm caused by pollution. Such policies generally exclude coverage for harm caused by the hazardous properties of nuclear material, but only if such harms would be insured by ANI. Thus, such policies would apply to hospital waste and other radioactive material not associated with nuclear power plants.[23]

Few insurers write EIL policies today. Of the insurers licensed in Massachusetts, apparently only American International Group (AIG) offers EIL policies.[24] AIG's current EIL policy limits are $20 million (aggregate) for a disposal facility and $10 million (aggregate) for a supplier or transporter. However, AIG would be unlikely to insure an LLRW facility that handles waste from a nuclear reactor, since its policy excludes coverage for harm caused by reactor waste and it would be too difficult to defend (or even identify the covered portion of) a claim involving a mixed shipment for disposal of reactor and non-reactor waste.

Although AIG's policies are available in Massachusetts, most Massachusetts companies that transport or dispose of hazardous waste have chosen the essentially cost-free option of participating in the State's Hazardous Waste Insolvency Fund (HWIF).[25] To the extent that an LLRW facility is also a hazardous waste disposal facility,[26] the HWIF would apparently also be available to cover third party liability claims. However, it is unclear whether the HWIF provides broader coverage than an EIL policy. EIL policies cover claims arising from release of pollutants while Chapter 21C, section 15, indicates that the HWIF covers

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[22] Henke. "Ohio's View of the Pollution Exclusion Clause: Is There Still Ambiguity?," Ohio State Law Journal. Ohio State University, Columbia, OH, 1989.

[23] ANI only insures radioactive waste associated with nuclear power plants because it limits itself to insuring risks that arise from the "waste cycle." The "waste cycle" is defined as all waste that is created at a nuclear power plant. ANI does not insure hospital waste because:

> They are all insured by the conventional insurance market. The reason for that, frankly, is that 27 years ago when the pools were created it was decided that the byproduct material exposure did not present any sort of catastrophic risk. It is in fact viewed as a commonplace activity, and one that the conventional insurance market was willing to insure. [J. Quattrocchi, L. Mariani, and R. Sanacore. "American Nuclear Insurers....On liability Insurance and LLW Management," The Radioactive Exchange, Washington, DC, 1983.]

[24] Companies entering the EIL policy arena include the St. Paul Companies, Inc., and the Underwriters at Lloyds of London. Both are offering more limited EIL coverage.

[25] The HWIF was created by Massachusetts General Laws c.21C (Chapter 21C), sections 15-30. It officially expires on July 1, 1994, but is expected to be extended by the Legislature, as has been the case in the past.

[26] An LLRW facility could be a hazardous waste facility within the terms of the HWIF enabling statute if it were to accept mixed waste for disposal. See the discussion of mixed waste in Chapter 8 of this volume.

claims "arising from operation of a hazardous waste...facility...." (emphasis added)

Hazardous waste facility licensees may participate in the HWIF if they show either that pollution liability insurance is not available or that the annual premiums for such insurance are more expensive than the annual assessments to be paid to the Fund. [310 CMR 30.910(1)(a)] If a licensee faces a third party claim and is found to be insolvent, the HWIF will defend or pay such claim. Section 18 of Chapter 21C limits liability to $3 million dollars per occurrence and $6 million dollars in the aggregate for judgments against a licensee arising out of a sudden accidental occurrence. The statute limits liability to $15 million dollars in the aggregate for judgments against a licensee arising out of a non-sudden accidental occurrence.

In 1988, the Legislature attempted to address the general lack of affordable EIL insurance with Massachusetts General Laws c.175G, which set up the Pollution Liability Reinsurance Corporation (PLRC), a quasi-public corporation that would contractually accept all or part of the financial responsibility for pollution liability claims, in exchange for allocable premium charges. The Corporation now has a board of directors but has been unsuccessful at obtaining either private or public funds. It is uncertain whether the Corporation will continue to exist, whether it will ever be funded, and whether it will ever be able to expand pollution liability insurance availability.

If pollution liability reinsurance were ever offered by the PLRC, it might (but might not) be available to an LLRW facility's insurer. Unlike the statute governing the HWIF, the PLRC statute does not specify hazardous waste facilities as potential insureds. Rather, only waste facilities on an approved list are to be eligible for reinsurance,[27] so it is possible that an LLRW facility would be excluded.[28] The Pollution Liability Reinsurance Corporation has not yet developed criteria for placing a facility on a list, so it is impossible to predict if LLRW facilities would be included.

(3) Nuclear Energy Liability (NEL) Insurance. NEL policies cover bodily injury and off-site property damage caused by the "nuclear energy hazard." ANI's Nuclear Energy Liability Policy (Facility Form) defines the term "nuclear energy hazard" as the radioactive toxic, explosive or other hazardous properties of nuclear material,[29] but only if:

(1) the nuclear material is at the [reactor, processing, treatment, storage, or disposal] facility or has been discharged or dispersed therefrom without intent to relinquish possession or custody thereof to any person or organization, or

(2) the nuclear material is in an insured shipment which is (a) in the course of transportation, including handling and temporary storage incidental thereto, within the territorial limits of the United States of America, its territories or possessions, Puerto Rico or the Canal Zone, and (b) away from any other facility.

NEL policies are currently available for LLRW facilities from ANI with a policy limit of $25 million per occurrence. While ANI maintains that the "damages" covered by the NEL policy do not include "equitable relief" such as governmental response costs for testing, monitoring, containment or clean-up, ANI recently

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[27] Section 1 of the Act defines "waste facility" as "any facility operated by any person or organization for the storage, treatment, processing or disposal of waste materials."

[28] Section 1 also provides: "The Corporation shall require that pollution liability policies acceptable for reinsurance under this chapter shall exclude all coverage for claims arising out of or in connection with a waste facility unless such waste facility is on an approved list established by the Corporation."

[29] "Nuclear material" means source material, special nuclear material or byproduct material.

developed a new endorsement that adds coverage for off-site environmental liability (including governmental response costs) arising out of either an "Extraordinary Nuclear Occurrence" (ENO) or a transportation incident. An ENO is a very large accident involving a nuclear reactor, and is defined as:

> "any event causing a discharge or dispersal of source, special nuclear, or byproduct material from its intended place of confinement in amounts off site, or causing radiation levels off site, which the Nuclear Regulatory Commission or the Secretary of Energy, as appropriate, determines to be substantial, and which the Nuclear Regulatory Commission or the Secretary of Energy, as appropriate, determines has resulted or will probably result in substantial damages to persons off site or property off site.... As used in this subsection, "off site" means away from "the location or the contract location" as defined in the applicable Commission indemnity agreement, entered into pursuant to section 2210 of this title." [42 U.S.C. Section 2014(j), 1990].

ANI believes that LLRW facilities are an insurable risk, partly because nuclear risks are highly regulated and relatively well known.[30] Nevertheless, ANI temporarily suspended writing policies for LLRW facilities due to "expanding environmental liabilities" and uncertainty over coverage boundaries.[31] This uncertainty resulted from litigation involving the Maxey Flats LLRW disposal facility, a former LLRW disposal site in Kentucky that closed due to environmental problems.[32]

The current $25 million liability limit imposed on NEL policies for LLRW facilities apparently stems from lingering concerns about potential liability. ANI also objects to other "difficult liabilities" imposed by statute such as strict liability and joint and several liability. However, while ANI states that it would be "unlikely" for the nuclear insurance pools to write a policy in a rebuttable presumption state like Pennsylvania, it makes no such statement with respect to states with other "difficult liabilities."[33] Indeed, the NEL policy is a no-fault policy that appears to be written for a strict liability regime.

(4) Supplier and Transporter (S&T) Insurance. Most utilities and most nuclear materials transporters carry an S&T policy, also available from ANI, which covers bodily injury and property damage caused during shipment of nuclear materials. ANI will currently write S&T policies for a maximum of $200 million per occurrence.

18.6 Regulatory Requirements and Insurance Needs

Federal and state regulations require certain financial protections for LLRW generators and other licensed to use, store, treat, transport and dispose of LLRW. These parties will also have varying insurance needs based on the risks involved in their role in the radioactive waste cycle, the scope of their current insurance policies, and the possibility of coverage by the policies of other actors within the cycle.

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[30] Quattrocchi, Ibid.

[31] Ibid.

[32] F. Boylan. "United States System: Insurance/Indemnity Protection: Nuclear Energy Risks," Alexander & Alexander, New York, NY, May, 1989. See the details about the Maxey Flats site problems in Appendix 1A of this volume.

[33] Quattrocchi, Ibid.

LLRW Generators

(1) Nuclear Reactor Facilities. Nuclear reactor facilities are required, by the Price-Anderson Act, to purchase nuclear liability insurance to cover bodily injury and off-site property damage to third parties. That insurance will cover a shipment of nuclear waste materials until it reaches a waste disposal facility. American Nuclear Insurers (ANI) writes such policies, which may have a maximum amount of liability of $200 million. In the event that liability for an occurrence exceeds $200 million, the Price-Anderson Act provides for a second and third layer of insurance (See Appendix 18A of this chapter).

(2) Other Generators of LLRW. Other LLRW generators, such as universities, hospitals, and manufacturers, will typically have Comprehensive General Liability (CGL) policies and possibly Environmental Impairment Liability (EIL) policies. In addition, non-profit nuclear research reactors, such as those at Massachusetts Institute of Technology, Worcester Polytechnic Institute, and the University of Massachusetts-Lowell, maintain an indemnity agreement with the NRC under 10 CFR 140, which provides $500 million of financial protection to these licensees. The "nuclear energy liability exclusion" in the CGL and EIL policies applies only if the harm results from the hazardous properties of nuclear material which is at, or originated at, an insured nuclear facility or is contained in spent fuel or waste. As one author notes, "if the sole nuclear exposure involves the use of source material or commercial radioactive isotopes, the activity will not be within the definition of "nuclear facility."[34] Accordingly, harm caused by release of commercial radioactive isotopes in a shipment of hospital waste should be covered by a typical EIL policy.

Transporters and Brokers of LLRW

Transporters of LLRW to storage or disposal facilities will have general vehicle insurance, which, like most CGL policies, will exclude coverage for pollution hazards. Transporters or brokers may also purchase EIL and Nuclear Energy Liability (NEL) policies. The Supplier and Transporter Insurance (S&T) policy is available only to transporters or brokers who handle "nuclear materials," which does not include radioactive hospital waste, for example. If transporters or brokers handle both hospital waste and reactor waste, they would be eligible to purchase an S&T policy. Note that transporters or brokers taking waste from a nuclear reactor will be covered by the reactor's NEL policy, and transporters or brokers taking waste to a storage or disposal facility will be covered by the facility's NEL policy.

As noted, the S&T policy is an "omnibus" policy under which the transporter or broker is the named insured, but everyone connected with the shipment would be defended and indemnified.

Facility Operator

NRC regulations for disposal facility licensure, Title 10 of the Code of Federal Regulations (CFR), Part 61, include requirements for general financial assurance by the license applicant. The applicant must demonstrate the ability to fund the costs of conducting all licensed activities over the operating life of the project, including costs of construction, operation, site closure, stabilization, and premature closure of the facility. [10 CFR 61.61 and 61.62]

No requirements exist in the regulations regarding provisions for liability insurance or other methods to indemnify property owners in case of off-site migration that might cause bodily injury or property damage. In the Federal Register notice of Dec. 27, 1982, announcing its final rule-making action on 10 CFR Part 61, regulations pertaining to licensing of near-surface LLRW disposal facilities, NRC commented that:

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[34] Boylan, Ibid.

"there is a need for licensees to provide financial responsibility for liability coverage for off-site bodily injury and property damage....The Commission will strongly encourage licensees to continue to carry third party liability insurance coverage through the conventional insurance market."

As noted earlier in this chapter, Massachusetts law, Chapter 111H, contains comprehensive provisions establishing responsibility for facility maintenance and remediation of on-site damage, with the facility operator responsible during construction, operation, closure, and post closure. A facility operator may either purchase first party insurance for property damage to its facility or self-insure for an amount appropriate to cover such damage.

A facility operator may also purchase liability insurance to cover bodily injury or off-site property damage to third parties. Facilities may purchase CGL, EIL and NEL policies. To be eligible for an NEL policy, a facility must accept some "nuclear materials" as defined by ANI. Basically, a facility would have to accept LLRW from nuclear reactors to become eligible for NEL insurance.

The NEL policy, like the S&T policy, is an "omnibus" policy under which the site operator is the named insured, but everyone connected with the site would be defended and indemnified.

Regulators and Monitors

Since, as discussed above, the State has waived sovereign immunity for negligence claims resulting from certain LLRW activities, the State and its subdivisions (cities, towns, and government agencies), may need to provide for funds sufficient to compensate third parties for bodily injury or property damage arising out of activities associated with the regulation or monitoring of LLRW. However, section 10 of the State's Tort Claims Act provides that the Commonwealth's waiver of immunity does not extend to negligence in the exercise of "governmental functions," such as improper regulation or enforcement. Traditionally, Massachusetts is self-insured, and does not carry third party liability insurance. With respect to the nuclear energy hazard, a facility operator's NEL policy would also cover the State.

A private contractor engaged to monitor LLRW management activities would also require insurance. The various types of insurance available would be the same as for LLRW generators: CGL, EIL and "omnibus" coverage under the site operator's NEL policy.

Facility Site Owner

As owner of the site upon which a storage, treatment, or disposal facility is developed pursuant to Chapter 111H -- a requirement of federal regulation -- the Commonwealth may possibly become responsible for cleanup of its property or for bodily injury, and off-site property damage or environmental damage arising from activities carried out by others on the owner's land. Massachusetts, like most other states, is traditionally self-insured for damage to its own property, as well as for liabilities to third parties. With respect to the nuclear energy hazard, a facility operator's NEL policy would cover the Commonwealth.

18.7 Insurance Requirements of Other States

Because the hazards of a storage, treatment, or disposal facility that has not been sited, and whose disposal method has not been selected, are impossible to evaluate accurately, it is helpful to look to other states with existing or proposed facilities to understand what might be a reasonable degree of financial assurance to require.

Either by state regulation, contract, or both, states with existing treatment or disposal or proposed disposal facilities generally require the facility operator to purchase some form of insurance. No state, however, requires any party other than the facility operator to purchase insurance.

Existing Facilities

None of the three states that had, through 1992, operated disposal facilities for LLRW generators throughout the nation (e.g. Nevada, Washington, and South Carolina) required insurance for LLRW management. Nevada required its facility operator (U.S. Ecology) to post a performance bond in the event a claim may arise, and US Ecology voluntarily carried a $15 million dollar NEL policy from ANI. Similarly, in Washington, facility operator U.S. Ecology voluntarily carries a $15 million NEL policy from ANI. U.S. Ecology has stated that the $15 million dollar policies were adequate because both sites are located in isolated, arid areas of their respective states.

In South Carolina, site operator Chem-Nuclear originally chose to purchase a $20 million NEL policy from ANI, but later purchased additional NEL insurance to raise its coverage to $100 million. This purchase pre-dated the current $25 million limit on NEL policies. Chem-Nuclear explains that it purchased the additional coverage, not because it reassessed the risk, but rather because the assets of the company had grown to such a point as to allow it to spend more on insurance.

Proposed Disposal Facilities

California requires the licensee of the disposal facility to carry nuclear liability insurance of no less than $10 million dollars "for both sudden and accidental or slow and gradual contamination to people or property off site." Five million dollars of first party insurance is also required. In addition, the Southwest Compact law allows California, as host state in the compact region, to access a disposal fee surcharge to finance a third party liability fund to cover damage claims during operation and after closure. The fund does not limit the operator's liability.

The two states that comprise the Northeast Compact, Connecticut and New Jersey, have been meeting with ANI to discuss future insurance policies. Both states have urged ANI to consider writing NEL policies for more than $25 million, but neither state has fixed a required minimum amount of third party liability insurance.

New Jersey law requires the site operator to be held liable, without regard to fault, for "all direct and indirect" damages, and the cleanup and removal of any discharges. While not requiring an explicit level of insurance for third party liability, the statutory language clearly indicates that the operator will have to purchase CGL, EIL and NEL policies.

Connecticut law requires a facility operator applicant to maintain third party liability insurance for sudden and non-sudden occurrences in the amount fixed by the State's LLRW management agency. In addition, a $10 million dollar disposal facility trust fund must be established to cover any liability not otherwise covered from insurance, or other forms of financial assurance.

Illinois requires its facility operator (Chem-Nuclear) to obtain a $100 million NEL policy. Since ANI is not writing policies for more than $25 million, Illinois has agreed to accept letters of credit from Chem-Nuclear for the remaining $75 million. Chem-Nuclear explains that Illinois chose the $100 million dollar figure based on the amount of coverage Chem-Nuclear has in South Carolina, an amount not based on any real risk assessment, but only on what the company could afford to buy at one point in time. The Illinois facility will serve the Central Midwest Compact region, which generates more than twice the waste volume produced in Massachusetts.

Illinois law also requires the establishment of a "Closure, Post-Closure Care and Compensation Fund" from which third party claims may be paid after the operator ceases to be responsible for the facility. The fund will be financed through disposal fee surcharges. Claims will be limited to the amount in the fund, unless the Illinois Legislature appropriates additional funds.

Nebraska law requires the facility operator to purchase property and third party liability insurance. Nebraska has not yet determined the required amounts. A "Radiation Site Closure and Reclamation Fund" must be financed by the operator (surety bonds, cash deposits, letters of credit, etc.) to cover licensed activities and corrective returns or cleanup, as well as providing funds to pay third party claims.

North Carolina requires its operator (Chem-Nuclear) to obtain:

- An NEL policy for $100 million;
- A CGL policy for $25 million per occurrence and $25 million in the aggregate;
- An EIL policy for $10 million per occurrence and $10 million in the aggregate.

North Carolina recognizes that ANI has a $25 million dollar limit on new NEL policies and the State will accept letters of credit from Chem-Nuclear for the remaining $75 million. State officials used the South Carolina NEL policy amount as a benchmark. The North Carolina facility will serve the Southeast Compact region, which generates 8-10 times the waste volume produced in Massachusetts.

Pennsylvania will require its operator (Chem-Nuclear) to carry an NEL policy for at least the amount of the capital cost of the facility (currently estimated by the State at $60 million), but not to exceed $100 million. Pennsylvania officials concede that there was no risk-based reason for the "cost of the facility" requirement. Chem-Nuclear believes that the capital cost of the facility will exceed $100 million because the amount includes every cost associated with construction, even the production of legal documents. The Pennsylvania facility will serve the Appalachian States Compact region, which currently produces about triple the waste volume generated in Massachusetts.

Pennsylvania recognizes that ANI is only writing policies for $25 million and will accept a letter of credit for whatever amount remains. A proposed contract with Chem-Nuclear will require a CGL policy for $1 million per occurrence. In addition, the contract will require Chem-Nuclear to carry an all-risk property insurance policy for the cost of the facility and various standard forms of insurance, such as workers compensation and automobile insurance.

The LLRW disposal site in Texas will be operated by the State, which intends to provide third party liability protection through insurance. No specific amount of insurance coverage has yet been determined. In addition, Texas law requires the creation of a special LLRW account, to be funded from disposal fees, that will pay third party damages if not covered by insurance.

Maine's law providing for LLRW management and disposal requires a $1 million self-insurance mechanism to cover third party liability. The money in this fund was to come from assessments on Maine Yankee.

18.8 Recommendations to Ensure the Adequacy of Insurance for LLRW Management

The adequacy of available insurance coverage cannot, in the final analysis, be determined

conclusively without reference to the specific activity or type of facility to be insured, and the circumstances for which insurance is provided.

It is especially difficult to assess risks associated with LLRW disposal activities because there is little experience with actual accidents involving LLRW. The largest claim ANI has ever received was for approximately $45-50 million to cover on-site cleanup of a contaminated shallow-land burial type of disposal site at Maxey Flats, Kentucky. Currently in litigation, ANI asserts that the claim is not a third party claim, and therefore is not covered by the facility's NEL policy. ANI representatives state that the company has received no third party claims arising from the activities of its insured LLRW facilities.

Conduct financial risk assessment. Adequacy in designing insurance protections for an LLRW storage, treatment, or disposal facility is a question best answered after a financial risk assessment is conducted to evaluate the potential hazards involved, the financial risks associated with those hazards, and the insurance or other financial mechanisms available to provide the necessary protection. Factors such as the size of the facility, the level of technology employed, its location, operating procedures, the types of waste accepted, and the criteria for acceptance, are all relevant in assessing insurance needs. All these factors are currently unknown with respect to any Massachusetts facility which may be determined to be necessary, but they will be identified during the process of preparing an Environmental Impact Report pursuant to Massachusetts General Laws, c.30, sections 61-62H. Such a report is mandated by Chapter 111H, section 30(c), regarding the proposed development, operation, closure, post-closure observation and maintenance, and institutional control of a Massachusetts LLRW facility.

Because this LLRW Management Plan includes a finding that no need exists to develop treatment capacity, and only a "future" need (i.e., beginning, at the earliest, after December, 1997) exists for storage capacity, the Management Board will require that any decision to site future treatment or storage facilities pursuant to Chapter 111H be followed by a financial risk assessment. The same types of insurance plans will be required (i.e., Comprehensive General Liability, Environmental Impairment Liability and Nuclear Energy Liability), but maximum limits will be determined with a consideration of the specific storage and treatment activities anticipated.

Insurance requirements for LLRW disposal facilities. Assuming the continued availability of the insurance policies described in this chapter, Massachusetts will follow the lead of other states that are cautiously developing LLRW disposal facilities with strict requirements for financial mechanisms to ensure defense and payment of third party claims, as well as the clean-up of a potential contaminated site. Accordingly, the Management Board will require any disposal facility operator to purchase the following insurance plans:

(1) All-Risk Property Insurance, to insure the facility itself (including costs of replacement of the buildings and equipment) in an amount equal to the facility's replacement cost, or the maximum amount available, whichever is less.

(2) Comprehensive General Liability Insurance, with minimum limits of $25 million per occurrence and $25 million in the aggregate;

(3) Environmental Impairment Liability Insurance, with minimum limits of $10 million, or such greater amounts, up to the maximum loss potential determined by a financial risk assessment acceptable to the Management Board, as may from time to time be commercially available.

(4) Nuclear Energy Liability Insurance, with minimum limits equal to $25 million or the maximum loss potential determined by a risk assessment acceptable to the Management Board. The facility operator will be required to agree to use its reasonable best efforts to obtain such insurance at the required amount. Since such insurance is not currently available in amounts

over $25 million, the facility operator will alternatively be required, through a letter of credit or other acceptable means, to establish an escrow arrangement equal to the difference between the available nuclear energy liability insurance policy limits and the required insurance amount.

Such an insurance program may be deemed adequate by the Management Board for an LLRW disposal facility if appropriate bond arrangements, acceptable to the Board, are made for on-site remedial action in amounts equal to the maximum loss potential determined by a financial risk assessment acceptable to the Management Board.

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Appendix 18A: The Price-Anderson Act

18A.1 Introduction

The Price-Anderson program is one of only a few federal programs that have imposed financial responsibility requirements as a condition of engaging in a particular enterprise. The Price-Anderson Act was enacted in 1957 and extended and amended in 1965, 1966, 1975, and 1988. The Act was designed to protect both the public and the nuclear energy industry by assuring the availability of funds for the payment of claims and by protecting the industry against unlimited liability in the event of a catastrophic nuclear accident. The Act requires each licensed nuclear power plant to "have and maintain financial protection... to cover public liability claims." The Act permits this financial protection to be in any form – insurance, contractual indemnities or self-insurance, for example – but, in practice, the insurance accessible through the program is the only third party liability protection actually available.

In form, the Act is different from other federal insurance mechanisms in that it provides, in effect, federal excess insurance for nuclear accidents. Funds would be made available to compensate those suffering losses caused by a nuclear accident through a combination of private insurance and government indemnity. The U.S. Nuclear Regulatory Commission (NRC) must require, as a condition for the issuance of licenses for nuclear power plants, that the licensee maintain financial protection for the payment of third party liability claims in the event of a nuclear accident.[1]

During the initial stages of nuclear technology, the government possessed a monopoly, which was deemed necessary at that time to meet military and national security needs. Other justifications of the monopoly were found in the fact that generating useful nuclear energy was believed to be a far distant goal, and health hazards of nuclear technology were unknown. By the time of the passage of the Atomic Energy Act of 1954, however, it became evident that greater private participation in nuclear development would make the generation of useful energy more immediately attainable.

In 1957, the maximum private liability insurance available to the nuclear industry was $60 million. Under the Price-Anderson Act, Congress had the government assume an indemnity of $500 million, and fixed the maximum liability for any nuclear accident at the sum of $560 million. This action was based on a policy of encouraging gradual growth in the nuclear power industry. Congress believed that the industry, in its early stages of development, was not capable of responsibly assuming the unique risk associated with nuclear accidents, which Congress believed to have extremely low probability, but potentially enormous consequences.[2]

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[1] For licensees intending to operate certain major power reactors, the Commission must require the maximum amount of insurance available from private resources. For other licensees, the commission may, at its discretion, require a lesser amount.

[2] S. Rep. No. 94-454, 94th Congress, 1st Session (1975), 1975 U.S. Code Cong. & Ad. News 2251.

As the amount of available private insurance increased, the government's indemnity under the law decreased, so that the sum of $560 million was continuously maintained. For example, at the end of 1975, the amount of private Insurance for nuclear accidents was $125 million and the government's Indemnity was therefore $435 million.

In 1975, Congress amended the Price-Anderson Act by adding a deferred or retrospective premium system. Licensees who were required to maintain the maximum amount of insurance available from private sources were now also required to participate in a retrospective rating plan whereby, in the event of a nuclear incident resulting in damages exceeding the "base layer" of insurance, each licensee would be assessed a deferred premium which would be a prorated share of the excess damages. The Commission set the level of the standard deferred premium at no less than $2 million per facility and no more than $5 million per facility.[3]

The clear goal of this amendment was a gradual phase-out of government indemnity. While some In Congress argued for an Immediate halt to the government's protection of the industry, Congress concluded that the industry was not capable of absorbing the cost of such an abrupt termination. To avoid the possibility of unduly disrupting the industry's development or of leaving the injured without protection In the event of a nuclear accident, the program was continued with the goal of termination by 1985. As more reactors were licensed, the secondary layer increased proportionately, and enabled the government indemnity to be phased out entirely by 1982. However, a termination of government indemnity of the nuclear risks did not signal a termination of the federal regulation of the amount of nuclear liability insurance required of licensees.

The 1988 amendments to the Act extended the authority of the Commission and the U.S. Department of Energy (DOE) to indemnify licensees to August 1, 2002. The secondary layer of coverage available per occurrence was raised based on a deferred premlum of $63 million dollars per operating plant with a maximum of $10 million dollars per plant, per year. With over 100 plants in operation, that figure now exceeds $6.3 billion ($1 billion per year). This increase was designed to bring the liability amounts set in 1954 Into comparable 1988 dollar amounts. Should damages exhaust this second layer of insurance, the Price-Anderson Act specifies that Congress will review the accident and take whatever action it decides is necessary and appropriate to protect the public.

18A.2 Coverage and Terms of Insurance

Three forms of nuclear insurance are currently available to owners and operators of nuclear power plants: replacement power insurance;[4] third party (liability) Insurance; and first party (property damage)

[3] If, for Instance, a deferred premlum of $3 million per reactor is set at a particular time and a total of 100 reactors had been licensed to operate up to that time, then $300 million would be available to provide payment of damages In this secondary layer of insurance, before any of the government Indemnity Is tapped.

[4] Replacement power coverage is offered by Nuclear Electric Insurance, Ltd. (NEIL), an electric utility self-insurance pool. NEIL covers 90% of the increased cost of any replacement power which must be purchased as a result of a nuclear power plant shutdown caused by an accident at the facility. Coverage begins after a plant has been shut down for six months and extends for two years of replacement power.

insurance.[5] Of all the federal insurance programs, only the nuclear energy program provides a broad general liability coverage scheme for personal injury as well as property damage. All other federal insurance programs compensate solely for property damage.

It is the liability coverage that satisfies the financial responsibility requirement of the Atomic Energy Act. Under the Price-Anderson program, such third party coverage is available from American Nuclear Insurers (ANI), a pool of insurance companies. This liability coverage is theoretically provided in three layers: the first $200 million is underwritten directly by ANI. Essentially, this is the amount of coverage capacity that private insurers have been able to amass over the years, as experience with nuclear power has encouraged insurer participation in the Price-Anderson program.

The second layer, which is currently in excess of approximately $6.3 billion, is provided by a retrospective assessment of up to:

> "$63,000,000 per facility (subject to adjustment for inflation under subsection (t) of this section), but no more than $10,000,000 in any one year, for each facility for which such licensee is required to maintain the maximum amount of primary financial protection; And provided further, that the amount which may be charged a licensee following any nuclear incident shall not exceed the licensee's prorata share of the aggregate public liability claims and costs excluding legal costs subject to subsection (o) (1) (D) of this section, payment of which has not been authorized under such subsection arising out of the nuclear incident. Payment of any State premium taxes which may be applicable to any deferred premium provided for in this chapter shall be the responsibility of the licensee and shall not be included in the retrospective premium established by the Commission."

The amount of liability assessed to each licensee will be adjusted "not less than once during each five-year period (following August 20, 1988), in accordance with the aggregate percentage change in the Consumer Price Index since (a) August 20, 1988, in the case of the first adjustment, or (b) the previous adjustment."

A third layer, provided by the United States government, covers liabilities with respect to licenses issued between Aug. 1, 1954, and Aug. 1, 2002, for which the NRC agrees to indemnify the licensee. The statutory provisions establishing these three layers of coverage have been recognized as having the purpose of establishing a liability fund to facilitate the rapid and adequate compensation of claims, if a nuclear accident should occur.

The form of the nuclear energy liability policy is provided by regulation of the Commission. The limits of liability are not on a "per occurrence" basis, as are many comparable insurance policies. Rather, because the primary layer of coverage represents the entire capacity of the insurance industry to provide liability coverage, any payments made under any one policy necessarily reduces the available coverage for a subsequent incident covered by the Price-Anderson program. After the incident, the pools may consider restoration for the original policy layer, but they are by no means compelled to do so, and restoration is certainly not accomplished automatically, as it is in most liability policies. Moreover, since the policy is continuous in terms, and has no fixed expiration date, any reduction in the primary layer continues to apply in subsequent policy years, until it is restored.

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[5] First party coverage is currently available from three insurance groups. Nuclear Mutual Ltd. (NML), an electric utility self-insurance pool, offers a primary layer of $450 million of first party coverage to its insured members. American Nuclear Insurers (ANI) offers $375 million of coverage to all nuclear power facility owners or operators. NEIL offers a secondary layer of coverage -- above that offered by NML or ANI -- of $118 million.

Although federal indemnification, for most practical purposes, terminated when the 80th nuclear power facility became insured in 1982,[6] entrance into an indemnification agreement with the Commission remains a prerequisite of licensing such a facility. Indeed, federal indemnification may still come into play in the event that the primary layer of coverage is reduced by reason of a nuclear incident, and not restored by the nuclear insurance pools. The terms of the required indemnification agreement are set forth by regulation.[7] The central feature of this agreement is that, in the event of an "extraordinary nuclear occurrence" (ENO), certain defenses must be waived that might otherwise be available to the operator of an insured facility in a tort action arising out of such an occurrence. These include defenses based upon the due care of the defendant; the conduct of the claimant (contributory or comparative fault, for example); the statute of limitations; or charitable or governmental immunity. The effect of these waivers is to establish the strict liability of the operator in the event of an ENO, regardless of state law that might otherwise be applicable.[8]

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[6] See "Feds' Nuclear Liability Nears End." National Underwriter. Cincinnati, OH, Dec. 24, 1982.

[7] 10 Code of Federal Regulations (CFR) §140.92.

[8] The issue of whether there has been an ENO can be very important whenever a claim arising out of a nuclear incident is made. As noted in Chapter 18, the Atomic Energy Act defines an ENO as:

> any event causing a discharge or dispersal of source, special nuclear, or byproduct material from its intended place of confinement in amounts off site, or causing radiation levels off site, which the NRC determines to be substantial, and which the commission determines has resulted or will probably result in substantial changes to persons off site or property off site.

While this definition may not appear to set a difficult threshold for a finding that an ENO has occurred, in fact, the only incident to which an effort has been made to apply the definition, the accident at Three Mile Island, has been found by the NRC not to constitute an ENO. This finding was based upon the recommendation of a panel established to investigate the TMI incident, which concluded:

> The first criterion, pertaining to whether the accident caused a discharge of radioactive material or levels of radiation off site as defined in 10 CFR 140.84, has not been met.... There is presently insufficient information to support any definitive finding as to whether or not the second criterion, relating to damage to persons or property off site as defined in 10 CFR 140.85, has been met. Since the Panel has not found that both criteria have been met, it recommends that the Commission determine that the accident at Three Mile Island did not constitute an "extraordinary nuclear occurrence."

The NRC adopted the panel's recommendation, despite the fact that a large number of legal claims arising out of the incident had been filed, alleging both off site discharges of radiation and damages to persons and property.

Appendix A: Chapter 111H. Massachusetts Low-Level Radioactive Waste Management Act

PUBLIC HEALTH

CHAPTER 111H. MASSACHUSETTS LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT ACT

§ 1. Definitions

As used in this chapter, the following words shall, unless the context clearly indicates otherwise, have the following meanings:—

"Affected community", a community, other than a site community, which is identified in an environmental impact report prepared pursuant to section thirty, and can be expected to experience significant impacts as a result of the location, development, operation, closure, post-closure observation and maintenance or institutional control of a facility.

"Board", the low-level radioactive waste management board established in section two which shall be responsible for planning and effecting the management of low-level radioactive waste in the commonwealth in accordance with the provisions of this chapter.

"Broker", a person engaged in the business of arranging for the collection, transportation, treatment, storage or disposal of low-level radioactive waste.

"Candidate site", a site, identified in accordance with the procedures established in section twenty, which will be the subject of detailed site characterization as part of the process to select any superior site.

"Candidate site community", a community in which is located all or any part of a candidate site.

"Chief executive officer", the city manager in any city having a city manager, the mayor in any other city, the town manager in any town having a town manager, the chairman of the board of selectmen in any other town.

"Citizens advisory committee", the committee established pursuant to section thirty and the regulations adopted by the secretary of the executive office of environmental affairs to facilitate public participation in the evaluation and review of the environmental impacts of a facility prior to licensing.

"Closure", the permanent termination of low-level radioactive waste acceptance at a facility, including closure prior to the scheduled closing date, and the implementation of a closure plan.

"Closure plan", the plan, required as a condition of a facility license, prepared pursuant to regulations adopted under section sixteen, to assure safe facility closure after operation.

"Community", a city or town of the commonwealth.

"Community compensation", any money, thing of value or economic benefit conferred by an operator or the board on any site or neighboring community under the terms and conditions specified in a comprehensive operating contract executed pursuant to section thirty-three.

"Community supervisory committee", a committee, established pursuant to section twenty-one, to facilitate the participation of a community, in which a candidate site is located, in the activities established by this chapter.

"Comprehensive operating contract", a contract entered into by an operator and the board pursuant to section thirty-three which specifies the community compensation to be provided by the operator or the board.

"Contingent liability account", an account within the Low-Level Radioactive Waste Trust Fund established in section forty-one for the purpose of compensating for injuries to persons, land or property, pursuant to section nine, if no other funds, insurance, tort compensation or other means of satisfying a damage judgment or settlement are available.

"Detailed site characterization", the on-site investigatory and analytical step of site selection established in section twenty-three and conducted prior to the selection of any superior site.

"Development", all activities undertaken with respect to a low-level radioactive waste facility during the period commencing with the selection of any superior site pursuant to section twenty-three and continuing until the commencement of facility operation pursuant to section thirty-nine.

"Development contract", a contract entered into by an operator and the board pursuant to section twenty-eight under which such operator shall be obligated to fulfill all of the requirements of the facility approval process established pursuant to sections twenty-nine through thirty-four inclusive.

"Disposal", the isolation of low-level radioactive waste from the biosphere inhabited by human beings and their food chains.

"Environmental monitoring program", a monitor program established by the department of public health, after consultation with the department of environmental quality engineering and the board of health of each site community, pursuant to section thirty-six for the purpose of collecting and analyzing environmental data prior to construction and throughout the construction, operation, closure, post-closure observation and maintenance and institutional control of a facility.

"Facility", a parcel of land, together with the structures, equipment and improvements thereon or appurtenant thereto, which, pursuant to this chapter, is being developed, is used, or has been used for the treatment, storage or disposal of low-level radioactive waste; but does not include any property used for temporary storage of low-level radioactive waste in sealed containers by a broker.

"Facility license", a license to operate a facility issued by the department of public health pursuant to section thirty-one.

"Generator", a person, including a broker, who produces low-level radioactive waste.

"Half-life", the time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form.

"Institutional control", the continued observation, monitoring, and care of a facility following transfer of the facility license from the operator to the board.

"Institutional control account", an account within the Low-Level Radioactive Waste Trust Fund established in section forty-one for the purpose of paying institutional control costs pursuant to sections nine and forty-seven.

"Low-level radioactive waste", radioactive material that (1) is neither high-level waste, nor spent nuclear fuel, not by-product material as defined in section 11(e)(2) of the Atomic Energy Act of 1954, as amended, 42 USC Section 2014(e); and (2) is classified by the Federal Government as low-level radioactive waste, but not including waste which remains a federal responsibility, as designated in section 3(b) of the Low-Level Radioactive Waste Policy Act, as in effect as of the effective date of this chapter, as amended, 42 USC Section 2021c(b).

"Low-level Radioactive Waste Trust Fund", a trust fund established pursuant to section thirty-five II of chapter ten which shall consist of surcharges collected from users of the low-level radioactive waste facility in an amount determined by the board on an annual basis, which shall be used to meet the obligations set forth in sections nine and forty-seven.

"Management", the storage, packaging, treatment, transportation, or disposal, where applicable, of low-level radioactive waste.

"Management plan", the low-level radioactive waste management plan adopted by the board pursuant to section twelve to provide for the safe and efficient management of low-level radioactive waste.

"Neighboring community", a community, other than a site community, which, according to the most recent federal census, has at least twenty per cent of its population residing within three miles of any superior site.

"Operator", a person designated in accordance with the procedures established in sections twenty-two and twenty-seven to develop and operate a low-level radioactive waste facility.

"Operation", the control, supervision or implementation of the actual physical activities involved in the acceptance, storage, treatment, disposal or monitoring of low-level radioactive waste at a facility and the maintenance of the facility and any other responsibilities of operation pertaining to the facility.

"Person", any agency or political subdivision of the federal government or the commonwealth, or of any state, any public or private corporation or authority, individual, firm, joint stock company, partnership, association, trust, estate, institution or other entity, and any officer, employee or agent of such person, and any group of such persons.

"Possible location", a location, identified in accordance with the procedures established in section twenty, which will be the subject of preliminary characterization.

"Post-closure observation and maintenance", the active monitoring and maintenance of a facility which has been closed in preparation for transfer of the facility's license from the operator to the board.

"Preliminary characterization", the investigatory and analytical step established in section twenty, and conducted prior to the identification of candidate sites.

"Professional training", the level of academic or on-the-job training generally recognized as adequate to qualify a person to be employed in a discipline.

"Public meeting", a public hearing, satisfying the requirements of section two of chapter thirty A, in which an agency presents information, responds to inquiries and hears testimony of interested persons.

"Shallow land burial", a land disposal method that relies on the site's natural characteristics as the primary barrier for isolation of the waste.

"Site community", the community in which is located all or any part of any superior site.

"Source minimization", minimizing the volume of radioactivity of low-level radioactive waste prior to its generation by such methods as: (1) avoiding unnecessary contamination of items during the use of radioactive materials; (2) carefully segregating radioactive waste from non-radioactive trash; or (3) substituting non-radioactive isotopes or radioisotopes with shorter half-lives where practicable.

"Storage", the holding of low-level radioactive waste for treatment or disposal.

"Storage for decay", a procedure in which low-level radioactive waste with a relatively short half-life is held for natural radioactive decay in compliance with applicable federal and state regulations.

"Superior site", any site selected by the board, after detailed site characterization, pursuant to section twenty-three.

"Temporary closure", the nonpermanent termination of low-level waste acceptance at a facility prior to its scheduled closing date.

"Treatment", any method, technique, or process, including source minimization, volume minimization and storage for decay, designed to change the physical, radioactive, chemical or biological characteristics or composition of low-level radioactive waste in order to render such waste safer for management, amenable for recovery, convertible to another usable material or reduced in volume.

"Volume minimization", treatment of low-level radioactive waste after its generation in order to minimize the physical dimensions of the waste and the space required for disposal.

"Waste management area", that portion of a facility where low-level radioactive waste has been, is being or will be treated, stored or disposed of.

Added by St.1987, c. 549, § 5. Amended by St.1992, c. 403, § 25.

Historical and Statutory Notes

1987 Legislation

St.1987, c. 549, § 5, adding this chapter consisting of this section and §§ 2 to 48, was approved Dec. 8, 1987, and by § 10 made effective upon passage.

1992 Legislation

St.1992, c. 403, § 25, in the definition of "Neighboring community", substituted "federal census" for "decennial census conducted pursuant to section seven of chapter nine".

Section 34 of St.1992, c. 403, provides:

"Any reference to the state census in any statute, charter, regulation, agreement, or other document shall be taken to mean the most recent federal census."

St.1992, c. 403, was approved Jan. 14, 1993. Emergency declaration by the Governor was filed Jan. 29, 1993.

§ 2. Low-level radioactive waste management board; establishment; appointment of members

(a) There is hereby established as an independent agency within, but not subject to the control of, the executive office of environmental affairs, the low-level radioactive waste management board. The board shall be responsible for planning and effecting the management of low-level radioactive waste in the commonwealth in accordance with the provisions of this chapter.

(b) The board shall consist of nine members appointed by the governor, one of whom shall be the secretary of the executive office of environmental affairs and one of whom shall be the secretary of the executive office of human services or their designees; provided, however, that no such designee may be an employee of the department of public health or the department of environmental protection. The remaining members of the board will be appointed by the governor from lists of candidates whose experience, background and professional training indicates that they can act in the public interest as follows: one of whom shall have professional training and experience in public administration shall be appointed from lists of nominees submitted by organizations with statewide membership that have demonstrated an interest in public or municipal management; one of whom shall have professional training and experience in engineering shall be appointed from lists of nominees submitted by organizations with statewide membership that have demonstrated an interest in engineering; one of whom shall have professional training and experience in a radiological health field shall be appointed from lists of nominees submitted by organizations with statewide membership that have demonstrated an interest in radiological health; one of whom shall have professional training and experience in business management shall be appointed from lists of nominees submitted by organizations with statewide membership that have demonstrated an interest in business management; and three of whom shall have professional training and experience in environmental protection shall be appointed from lists of nominees submitted by environmental organizations with statewide membership that have demonstrated an interest in low-level radioactive waste management. The governor shall make the initial appointment of such membership by November thirtieth, nineteen hundred and eighty-seven and shall make subsequent appointments no more than sixty days after a vacancy occurs, but shall not appoint any particular member unless at least three nominations have been submitted by appropriate organizations; provided, however, that additional members shall be appointed to the board upon the selection of a superior site as follows: the chief executive officer of each site community in which is located a facility that is in development, operation, closure, post-closure observation and maintenance or institutional control pursuant to this chapter, shall appoint a community resident to serve as a member of the board; and provided, further, that if there is only one site community in the commonwealth, the chief executive officer of the neighboring community having the

greatest population residing within three miles of the superior site, shall also appoint a community resident to serve as a member of the board, but, if no community is eligible for such appointment, the chief executive officer of the site community shall appoint a second community resident to serve as a member of the board.

Added by St.1987, c. 549, § 5. Amended by St.1990, c. 177, § 199; St.1991, c. 138, § 43.

Historical and Statutory Notes

1987 Legislation

Sections 6 and 7 of St.1987, c. 549, provide:

"Section 6. The low-level radioactive waste management board, established under the provisions of section two of chapter one hundred and eleven G of the General Laws, is hereby authorized and directed to represent the commonwealth in any and all negotiations with other states for the purpose of reaching an interstate compact agreement to provide for the establishment and operation of regional disposal facilities for low-level radioactive waste. In carrying out the duties established hereunder, said board may initiate negotiations with any state it deems appropriate to meet the needs of the commonwealth with respect to such facilities upon a majority vote of the board. The board shall include as part of its management plan adopted pursuant to section eleven of chapter one hundred and eleven H of the General Laws a detailed report which shall include a summary of all negotiations conducted prior to the establishment of the board, a study of the feasibility of the commonwealth entering into a regional compact which shall identify those states the board deems appropriate for the commonwealth to negotiate with. After the issuance of the detailed report the board shall report semiannually to the joint committee on natural resources on its progress in its negotiations for a regional compact which shall include any additional states which the board determined it is appropriate to negotiate with or any other developments which impact on the establishment of an interstate compact, including any cost to the commonwealth for the disposal of low-level radioactive waste or the volume of waste to be stored in the commonwealth arising from the regional compact negotiations.

"Section 7. The governor, on behalf of the commonwealth, may enter into an agreement with the federal nuclear regulatory commission under section 274 of the Atomic Energy Act of 1954, providing for discontinuance of the regulatory authority of the commission with respect to low-level radioactive waste, by-product, source, and special nuclear material, and the assumption by the commonwealth of the authority to regulate the materials covered by the agreement for the protection of the public health and safety from radiation hazards.

"Any person who, on the effective date of an agreement entered into pursuant to this section, possesses a license issued by the federal nuclear regulatory commission for radioactive materials subject to such agreement shall be deemed to possess a like license issued under section five N of chapter one hundred and eleven of the General Laws. Within ninety days of the effective date of such agreement, the department shall reissue such license on such forms as it may require by regulation; provided, however that such reissued license shall expire on the date of expiration specified in the nuclear regulatory commission license."

1990 Legislation

St.1990, c. 177, § 199, an emergency act, approved Aug. 7, 1990, in par. (b), in the first sentence, substituted "protection" for "quality engineering".

1991 Legislation

St.1991, c. 138, § 43, approved July 10, 1991, and by § 393 made effective as of July 1, 1991, in par. (a), in the first sentence, substituted "as an independent agency within, but not subject to the control of, the executive office of environmental affairs" for "within the executive office for administration and finance".

The Governor's purported disapproval in part of St.1991, c. 138, § 43, was held invalid. See Opinion of the Justices (1991) 582 N.E.2d 504, 411 Mass. 1201.

§ 3. Board members; term of office; board actions; meetings

(a) Except as hereinafter provided, each member of the board shall serve for a term of seven years. Board members initially appointed shall serve as follows: the public administration member shall serve for a term of three years; provided, however, that the appointment of a public administration member to succeed the initial public administration member shall serve for a term of five years; of the three environmental protection members, one shall serve for a term of three years, one shall serve for a term of four years, and one shall serve for a term of five years; provided, however, that the appointment of an environmental protection member to succeed the environmental protection member appointed for a term of three years, shall serve for a term of six years; the engineering member shall serve for a term of six years; the business management

member shall serve for a term of seven years; and provided further, that the term of each initial member appointed to the board shall expire on the first day of July in the year following the respective terms of appointment.

(b) Members appointed by the chief executive officer of a site or neighboring community shall serve at the pleasure of such chief executive officer, provided, however, that the terms of office of such members shall expire upon the decision of the board to terminate development of a facility at a superior site or upon termination of institutional control of the facility at the superior site pursuant to section forty-seven.

(c) Except as otherwise provided in this chapter, board actions shall require a majority vote of its members. A roll call vote shall be required upon request of any member. The governor shall appoint the initial board chairperson from among the members of the board who shall serve as chairperson until the first day of July next following such appointment. Thereafter, the board shall annually elect a chairperson from among its members. Board members not otherwise employed by the commonwealth shall each receive fifty dollars for each day or part thereof for their services, and all members shall be reimbursed by the commonwealth for all reasonable expenses actually and necessarily incurred in the performance of their official duties.

(d) The board shall meet at least monthly and shall also meet upon the call of the chairperson or a majority of its members. All meetings of the board shall be conducted in accordance with the provisions of section eleven A and one-half of chapter thirty A.

Added by St.1987, c. 549, § 5.

§ 4. Powers and duties of board; acceptance of donations, loans or grants

(a) The board shall have the following powers and duties:

(1) to take any action authorized by this chapter either directly or through, or by means of, its own officers, agents or employees, or by contract with any person, including, but not limited to, the adoption of a management plan pursuant to section twelve; the adoption of regulations governing the selection of operators pursuant to section fifteen; the certification of any operator applicants, pursuant to section twenty-two, who satisfy the board's regulatory criteria; the selection of any superior site pursuant to section twenty-three; the execution of a comprehensive operating contract pursuant to section thirty-three; the approval of a schedule of fees and waste acceptance criteria submitted by any operator, pursuant to section thirty-eight; the administration of the Low-level Radioactive Waste Trust Fund established in section forty-one; and the acceptance of the transfer of any facility license from the operator at the commencement of institutional control of the facility pursuant to section forty-six;

(2) to adopt such regulations as are necessary to accomplish the purposes of this chapter, including regulations governing its procedures;

(3) to call to its assistance and avail itself of the services of such employees of any federal, state, county or municipal department, board, commission, or agency as may be required and made available;

(4) to adopt regulations governing its use of consultant services, and the use of consultant services by community supervisory committees established pursuant to this chapter, which shall establish the rate of compensation for such services; provide for the prior approval by the board, of any such services for which no rate has previously been established by regulation; and require, at a minimum, that any such consultant shall satisfy the standards of conduct provided in section twenty-three of chapter two hundred and sixty-eight A; provided, however, that, except as provided in this section, such regulations shall be consistent with the regulations of the commissioner of administration adopted pursuant to section twenty-nine A of chapter twenty-nine unless the board determines that an inconsistent regulation is necessary to accomplish the purposes of this chapter;

(5) to adopt regulations governing the provision of technical assistance and planning funds to enable community supervisory committees to be established and to participate in the activities established by this chapter;

(6) to conduct continuing public participation and informational programs in accordance with section six;

(7) subject to the provisions of this section, to accept, receive, utilize, and dispose, for any of its purposes and functions, any and all donations, loans, grants or reimbursements of money, equipment, supplies, materials, and services, conditional or otherwise, including any payments made pursuant to section 5(d) of the Low-Level Radioactive Waste Policy Act, as amended 42 USC section 2021e(d), from any state or the United States or agency or political subdivision thereof, or interstate agency, or from any person;

(8) to acquire, by purchase or eminent domain, through the division of capital planning and operations, such interests in land as are necessary to conduct site selection activities pursuant to sections twenty and twenty-three or develop a facility at any superior site selected pursuant to said section twenty-three;

(9) to issue annually, no later than November thirtieth, a report of its activities, which shall be transmitted to the clerk of the senate, the clerk of the house of representatives, the governor, and the chief executive officer of each site, neighboring and affected community, and shall include:

(A) a list of the time, location and subjects of all meetings and adjudicatory proceedings conducted during the year and the minutes thereof;

(B) a list and description of regulations adopted during the year;

(C) a description of all activities undertaken pursuant to sections eighteen to twenty-three, inclusive, during the year;

(D) the most recent management plan adopted by the board; and

(E) a list of any reports prepared during the year; and

(10) to prepare and submit to the commissioner of administration an estimate, required to be filed under section three of chapter twenty-nine, of the amount required for the maintenance of the board, including any costs of providing funds to community supervisory committees pursuant to section twenty-one.

(b) The board shall establish regulations for the acceptance of donations, loans, grants of money, equipment, supplies, materials, and services. The nature, amount and conditions, if any, attendant upon any donation, loan, or grant accepted pursuant to this section, together with the identity of the donor, grantor, or lender, shall be made public. No donor, lender, or granter shall derive any advantage in any proceeding before the board by reason of such donation, loan or grant.

Added by St.1987, c. 549, § 5.

§ 4A. Low Level Radioactive Waste Management Fund; assessments

(a) There is hereby established on the books of the commonwealth a separate fund, to be known as the Low Level Radioactive Waste Management Fund. For the purpose of providing funds to implement the management plan adopted pursuant to section twelve and to carry out the powers and duties conferred by this chapter, the board shall annually assess each person licensed or registered to receive, possess, use, transfer or acquire radioactive materials in the commonwealth, amounts sufficient to defray the costs annually incurred by the board for such purposes. Amounts assessed shall be deposited in said fund and may be expended by the board, subject to appropriation, to carry out the powers and duties conferred by this chapter. The total amount to be assessed shall be apportioned annually in accordance with a schedule, sufficient to produce an amount not to exceed five hundred thousand dollars, adopted by regulation by the board, after notice to interested persons and a public hearing. In establishing such schedule, the board shall reduce the total amount to be assessed by the amount of any other donations, loans, grants, reimbursements, payments or unexpended assessments received, or other funds appropriated to implement the management plan and to carry out the powers and duties conferred by this chapter. Such schedule shall be based on the volume and classification of radioactivity of waste produced by each licensee and registrant which is shipped for disposal off site or stored for later disposal; provided, however, that the board shall make

a minimum assessment on all licensees and registrants. Such schedule may further provide for surcharges based on the classification scheme contained in the management plan. Assessments shall be due and payable not less than ninety days after written notice to the person upon whom such assessment is imposed, and shall accrue interest at twelve percent per annum on and after the due date. Failure without just cause to pay any lawful assessment pursuant to this section shall constitute a violation of this section.

(b) The board may, subject to appropriation and by an equitable method established by regulation, refund to persons who have paid an assessment pursuant to this section, the amount by which the assessments, interests and penalties collected in the prior fiscal year pursuant to this section and section four B exceeds the amounts expended by the board, including fringe benefits, for the purposes specified in this section.

(c) The board shall, on or before July first of each year, submit to the governor and the house and senate committees on ways and means, an annual report of the assessments, interest and penalties collected pursuant to this section and section four B for the previous fiscal year. Said annual report shall include a statement of disbursements for that fiscal year from said fund, and any other information the board deems appropriate.

(d) Nothing in this section shall be construed to relieve the board of its duty, pursuant to section four, to prepare and submit to the secretary of administration and finance an estimate of the amount required for the maintenance of the board, or of its duty, pursuant to section nine E of chapter twenty-nine, to notify said secretary and the house and senate committees on ways and means if the appropriation for the implementation of the management plan and to carry out the powers and duties conferred by this chapter will be insufficient to meet all of the expenditures required in the current fiscal year and of the estimated amount of such additional requirements.

(e) No assessment shall be due and payable pursuant to this section after June thirtieth, nineteen hundred and ninety-three, unless the board has submitted the schedule of assessments it has adopted to the house and senate committees on ways and means at least ninety days prior to sending any notice of such assessment pursuant to this section.

Added by St.1991, c. 138, § 166.

Historical and Statutory Notes

1991 Legislation

St.1991, c. 138, § 166, was approved July 10, 1991, and by § 393 made effective as of July 1, 1991.

§ 4B. Violations of section 4A; civil penalties

(a) If the board finds, after notice of any violation of section four A and an opportunity for a hearing have been provided, that any person is not in compliance with any requirement of section four A, or with any provision of any regulation adopted thereunder, it may assess civil penalties in an amount determined pursuant to this section. Such civil penalty may be imposed whether or not the violation was willful. In determining the amount of the civil penalty, the board shall consider the willfulness of the violation; the actual and potential cost to the commonwealth of collecting the assessment and penalty to enforce such requirement; whether the person being assessed the civil penalty did everything reasonable to pay the assessment, and to pay promptly after a notice of violation was issued; whether the person being assessed the civil penalty has previously failed to comply with any requirement of section four A, or with any provision of any regulation adopted thereunder; the financial condition of the person being assessed the civil penalty. The board shall also consider the goals of making compliance less costly than noncompliance, deterring future noncompliance, and the public interest.

(b) In addition to assessing civil penalties under this section, the board may request the attorney general to bring an action in the superior court to compel payment of assessments and penalties and immediate and full compliance with any order issued by

the board. The expense of the proceedings shall be recoverable from the violator in such manner as provided by law.

Added by St.1991, c. 138, § 166.

Historical and Statutory Notes

1991 Legislation

St.1991, c. 138, § 166, was approved July 10, 1991, and by § 393 made effective as of July 1, 1991.

§ 5. Executive director; duties

The board, after an open and competitive selection process, shall appoint a full-time executive director based on demonstrated competence. The executive director shall serve at the pleasure of the board and may appoint, discharge, contract for, compensate, or otherwise provide for such additional staff and consultants, as he determines necessary to carry out the board's duties and functions; provided, however, that the appointment of principal staff must be approved by a majority vote of the board. The executive director shall be the chief administrative officer of the board. Except where a vote of the board is required by this chapter, the board may delegate to the executive director full authority to carry out its duties and functions, subject to such conditions and instructions as the board may deem appropriate.

Added by St.1987, c. 549, § 5.

§ 6. Public participation coordinator; duties

The executive director, after an open and competitive selection process, shall appoint a full-time public participation coordinator based on demonstrated competence subject to approval by a vote of the board. The public participation coordinator's duties shall include:

(a) to encourage and facilitate the participation of interested persons in all of the processes established in or pursuant to this chapter;

(b) to make recommendations to the board, the department of public health and the department of environmental protection concerning the implementation of programs to assure appropriate public participation in the processes established in or pursuant to this chapter;

(c) to publicize throughout the commonwealth the management plan adopted pursuant to section twelve, all plans for the selection of any superior site or for the selection of an operator, and any proposals for the development, operation and closure of facilities in order to inform the public and to encourage and facilitate the participation of interested persons in such selection procedures, in environmental review and licensing proceedings, and in the review of facility operations; and

(d) to publicize throughout the commonwealth and to conduct continuing public informational programs on the use of radioactive materials, the nature and characteristics of low-level radioactive waste, current and developing technologies, and the hazards associated with low-level radioactive waste and the improper management thereof; provided, however, that, in establishing and conducting such programs, the public participation coordinator shall obtain the advice and assistance of an advisory board to be composed of members representing the range of public opinion concerning low-level radioactive waste or its management and invite the participation of persons representing such range of public opinion.

Added by St.1987, c. 549, § 5. Amended by St.1990, c. 177, § 200.

Historical and Statutory Notes

1990 Legislation

St.1990, c. 177, § 200, an emergency act, approved Aug. 7, 1990, in cl. (b), substituted "protection" for "quality engineering".

§ 7. Information concerning type, volume, radioactivity, source and characteristics of low-level radioactive waste; inspections; confidentiality

(a) For the purpose of ensuring the accuracy and completeness of the low-level radioactive waste management plan or of determining compliance with this chapter or any regulations adopted hereunder, each person who generates, treats, stores, transports or disposes of low-level radioactive waste within the commonwealth shall annually, and at such other times as requested by the department of public health, provide detailed and accurate information concerning the type, volume, radioactivity, source and characteristics of the low-level radioactive waste which such person generates, treats, stores, transports or disposes of; as well as such person's current and projected low-level radioactive waste management activities, including source minimization, volume minimization, on-site storage, treatment, packaging and transportation practices and such other information as the board or the department of public health deems necessary. The duly authorized inspectors of said department may, at all reasonable times, enter and examine any property, facility, or activity involving the management of low-level radioactive waste. The owner, operator and other person in charge of the property, facility, or activity, shall afford such inspectors unfettered access, equivalent to access provided to persons regularly employed at such property, facility or activity, following proper identification and compliance with applicable access control measures for security, radiological protection and personal safety. Such inspectors are authorized to make such inspections, conduct such tests, reviews, studies, monitoring, or sampling or examine books, papers and records as said department deems necessary for the administration or enforcement of this chapter.

(b) Notwithstanding the provisions of any general or special law to the contrary, any information, record or particular part thereof, obtained by the department of public health pursuant to the provisions of this chapter, shall, upon request by the owner or proprietor thereof, be kept confidential and not be considered to be a public record when it is determined by said department that such information, record, or report, relates to secret processes or methods of manufacture or production, or that such information, record or report, if made public, would divulge a trade secret. Nothing in this section shall prevent use of such information in the preparation of the management plan, or of any summary or statistical compilation of information obtained by said department.

(c) All procurement activities and all payments made under contracts entered into pursuant to this chapter including any development contract and any comprehensive operating contract, shall be deemed to be within the jurisdiction of the office of the inspector general in accordance with chapter twelve A.

Added by St.1987, c. 549, § 5.

§ 8. Issuance of orders; notice and opportunity for hearing; civil penalties; injunctions and actions to compel

(a) The department of public health may issue orders as are reasonably necessary for the enforcement of the provisions of this chapter. Such orders may include, but not be limited to orders modifying, suspending, or revoking licenses and orders requiring persons to cease any activity that is in violation of the provisions of this chapter or of any regulation adopted or facility license issued hereunder. Such orders shall be issued after notice and an opportunity for hearing except where public health, safety or the environment would be threatened by delay in the issuance of such order. In such circumstance, an opportunity for hearing shall be provided promptly after issuance of such order.

(b) If the department of public health finds, after notice and an opportunity for a hearing has been provided, that any person is not in compliance with any order issued pursuant to this section, or with any provision of this chapter or any regulation adopted hereunder, it may assess civil penalties in an amount not exceeding one hundred thousand dollars for each such violation. Such civil penalty may be assessed whether or not the violation was willful. In determining the amount of the civil penalty, the said department shall consider the willfulness of the violation; the actual and potential danger or injury to the public health or the environment; the actual and potential cost of such damage or injury; the actual and potential cost to the commonwealth of enforcing the provisions of this chapter; whether the person being assessed the civil penalty did everything reasonable to prevent the failure to comply from occurring, and to promptly come into compliance, and to remedy and mitigate whatever harm might have been done as a result of the failure to comply; whether the person being assessed the civil penalty has previously failed to comply with any order issued pursuant to this section, or with any provision of this chapter or any regulation adopted hereunder; making compliance less costly than noncompliance; deterring future noncompliance; the financial condition of the person being assessed the civil penalty; and the public interest.

(c) In addition to assessing civil penalties under this section, the department of public health may request the attorney general to bring an action in the superior court to restrain, prevent or enjoin any conduct prohibited by this chapter and to compel action to comply immediately and fully with any order issued by the department. The expense of the proceedings shall be recoverable from the violator in such manner as provided by law.

(d) It shall be unlawful for any person to willfully:

(1) violate or assist in the violation of any of the provisions of this chapter or of any regulations adopted hereunder;

(2) fail to comply with any order issued by the department of public health pursuant to this section;

(3) attempt to obtain a license by misrepresentation or failure to disclose all relevant facts.

(e) Any person convicted of unlawful conduct as defined in this section shall, for each offense, pay a fine of not less than one thousand nor more than twenty thousand dollars; or be imprisoned for a period of not more than twenty years; or both. Each day of continued violation of any provision of this chapter or of any regulation adopted or order issued hereunder shall constitute a separate offense.

Added by St.1987, c. 549, § 5.

§ 9. Management of low-level radioactive waste; liability; damages; funds to satisfy liability

(a) It shall be the responsibility of the operator to take all appropriate steps to clean up and stabilize the facility and to contain migration of low-level radioactive waste or associated toxic materials, whenever there has been or impends a release of such materials at the facility during its operation, closure or post-closure observation and maintenance. The board shall ensure that the operator has sufficient funds to satisfy this responsibility. The board shall have such responsibility during the period of institutional control and shall utilize sums from the institutional control account within the Low-Level Radioactive Waste Trust Fund established pursuant to section forty-one to satisfy this responsibility. If all other sources of funds, including federal assistance, have been exhausted, the commonwealth shall provide the reasonable costs of clean-up and stabilization of a facility.

(b) Except as otherwise provided in this section, any person who carries on any activity involving the management of low-level radioactive waste shall be subject to strict liability for harm to persons, land or property resulting from such activity when caused by any release of, or exposure to, such waste or associated toxic materials. Such liability may be joint and several unless such person establishes by a preponderance of the evidence that only a portion of such harm has resulted from such activity. No claim for such harm may

be made against the operator after a facility's license has been transferred to the board pursuant to section forty-six, unless the operator has willfully misrepresented the conditions of the facility at the time of such transfer or fraudulently concealed information about the facility or its operations.

(c) Notwithstanding the provisions of this section, the board, community supervisory committees, the department of public health, the department of environmental protection and the deputy commissioner of the division of capital planning and operations shall be subject to liability for harm to persons, land or property resulting from the management of low-level radioactive waste only in accordance with the provisions of chapter two hundred and fifty-eight; provided, however, that the amount of damages for which liability may be imposed shall not be subject to the limit provided in section two of said chapter two hundred and fifty-eight. Notwithstanding any limitation contained in said chapter two hundred and fifty-eight, but in accordance with the procedures established therein, the board shall be subject to liability for harm to persons, land or property which may occur after the board assumes its responsibility for institutional control of the facility pursuant to section forty-six, or from the negligence of any employee of the board in the institutional control of the facility.

(d) The board shall ensure that the operator has sufficient funds to satisfy its liabilities under this section, and for the compensation of injured facility employees. The board shall utilize sums from the institutional control account established in section forty-one to ensure the availability of funds to satisfy its liabilities under this section for which claims are made during the period of institutional control; provided, however, that the funds available to satisfy such liabilities from third party claims shall be at least equal to the maximum amount available from the nuclear insurance pools or other commercial insurers.

(e) If no other funds, insurance, tort compensation or other means of satisfying a damage judgment or settlement, approved by a court of competent jurisdiction, are available, the contingent liability account established in section forty-one shall be utilized to compensate for injuries to persons or property resulting from the management of low-level radioactive waste or the institutional control of a facility.

(f) The commonwealth shall provide compensation for harm to persons, land or property which may occur after the board assumes its responsibility for institutional control of the facility pursuant to section forty-six, only, if all other sources of funds, including federal assistance, have been exhausted.

Added by St.1987, c. 549, § 5. Amended by St.1990, c. 177, § 201.

Historical and Statutory Notes

1990 Legislation

St.1990, c. 177, § 201, an emergency act, approved Aug. 7, 1990, in par. (c), in the first sentence, substituted "protection" for "quality engineering".

Cross References

Proceeds from Low-Level Radioactive Waste Trust Fund, see c. 10, § 35I.

§ 10. Phase I of the Low-Level Radioactive Waste Management Act; planning

Planning for low-level radioactive waste management shall be conducted, subject to appropriation, in accordance with sections eleven to seventeen, inclusive, which shall be known and cited as "Phase I of the Low-Level Radioactive Waste Management Act". The provisions of such sections shall be implemented so as to require appropriate source minimization, volume minimization and storage for decay; to require a comprehensive management plan, an appropriate determination of need, and adequate regulatory controls and site selection criteria prior to the initiation of site selection; and to prohibit shallow land burial.

Added by St.1987, c. 549, § 5.

§ 11. Procedures for adoption of management plan

(a) The adoption of a management plan under section twelve the adoption of regulations for source minimization, volume minimization and storage for decay under section thirteen, the adoption of regulations for the selection of any superior site under section fourteen the adoption of regulations for operator selection under section fifteen and the adoption of regulations for the licensing of any facility under section sixteen shall be in accordance with the procedures set forth in this section. The recommendations of the public participation coordinator, made pursuant to section six, shall be implemented to the extent feasible in order to ensure appropriate public participation during the development of such plans and regulations; to ensure that adequate information concerning such plans and regulations is available; to facilitate the conduct of public meetings and other opportunities for public review and comment; and to ensure that public concerns are identified and addressed throughout the development of such plans and regulations.

(b) No fewer than four months prior to the initial adoption of a management plan pursuant to section twelve and the initial adoption of regulations under section thirteen to sixteen, inclusive, the responsible agencies shall issue drafts of such management plan and regulations, together with summaries thereof, for public review and comment. No fewer than thirty days and no more than ninety days after the issuance of such drafts, the responsible agencies and the public participation coordinator shall jointly conduct a minimum of six consolidated public meetings throughout the commonwealth on the drafts and shall accept written comments thereon. Such consolidated public meetings shall be conducted at times and locations to be agreed by the responsible agencies and the public participation coordinator.

(c) The management plan and any regulations adopted under any of sections thirteen to sixteen, inclusive, shall be adopted in accordance with the requirements of sections two to six, inclusive, of chapter thirty A; provided, however, that a public hearing satisfying the requirements of section two of said chapter thirty A shall be required prior to the adoption, amendment or repeal of the management plan or any such regulation.

(d) The initial management plan developed under section twelve and the initial regulations developed under sections thirteen to sixteen, inclusive, shall be adopted by January first, nineteen hundred and eighty-nine.

Added by St.1987, c. 549, § 5.

§ 12. Preparation, adoption by regulation, and implementation of management plan; contents of plan

(a) The board shall prepare, adopt by regulation, and implement a management plan to provide for the safe and efficient management of low-level radioactive waste. The primary consideration guiding the development of the management plan shall be the protection of public health, safety and the environment. The management plan shall be reviewed annually and revised as necessary.

(b) The management plan shall include, but not be limited to:

(1) a classification system, compatible with federal requirements and the regulations adopted by the department of public health under section sixteen, for all low-level radioactive waste generated, treated or disposed of in the commonwealth, based primarily on its radiological toxicity and radioactive half-life and also on the principal radionuclides present in the waste and their concentrations; its specific radioactivity; its chemical and biological toxicity and form; its chemical reactivity; its volume and such other characteristics as the board deems necessary to determine which classes of low-level radioactive waste may be stored for decay, which classes of low-level radioactive waste will require disposal and which classes will require special management procedures in order to facilitate the safe and timely closure, post-closure observation and maintenance and institutional control of the facility accepting such low-level radioactive waste;

(2) a review and analysis of current and developing low-level radioactive waste management technologies and practices, including their potential public health, safety and environmental impacts; their cost-effectiveness; their climatic, geologic, hydrogeologic,

or other requirements; and their suitability for the low-level radioactive waste managed within the commonwealth; and any recommendations for regulatory or other actions to improve the safety or efficiency of such technologies and practices, and to ensure that the value of property in the vicinity of any facility is maintained;

(3) an inventory of all generators located in the commonwealth or whose low-level radioactive waste is to be accepted for treatment, storage or disposal within the commonwealth, including information on their location, products, services, clinical procedures, and teaching or research activities and an evaluation of the economic benefit to the commonwealth of such products, services and activities; the volume, characteristics and curies of their current and projected generation of low-level radioactive waste in compliance with any regulations adopted by the department of public health pursuant to section thirteen; and their current and projected low-level radioactive waste management activities including source minimization, volume minimization, on-site storage, treatment, packaging and transportation practices;

(4) an inventory of all facilities within or outside the commonwealth under development or available to accept low-level radioactive waste generated within the commonwealth, including information on their location, size and capacity, and on the volume, characteristics and curies of the low-level radioactive waste accepted or to be accepted at such facilities; and projections of the anticipated future capacity and availability of such facilities to meet future needs;

(5) a finding as to whether there is a requirement for additional facility capacity to meet present low-level radioactive waste management needs or needs anticipated to arise within the next decade, a specification of the volumes and classifications of low-level radioactive waste to be accepted during operation of such a facility and the minimum land area requirement of such a facility, and a statement of the factual basis of such finding and specification;

(6) a review and analysis of proposals for, and the utilization of, all low-level radioactive waste transportation routes, practices, regulations and emergency response and enforcement capabilities employed within the commonwealth;

(7) a report of all facilities in operation, temporary closure, closure, post-closure observation and maintenance or institutional control including the results of the most recent financial audit of each facility conducted by the state auditor pursuant to section thirty-eight; an analysis of fees being collected by the operator to demonstrate the financial integrity of its operation; the expected availability of sufficient funds to carry out facility closure and post-closure observation and maintenance; the expected adequacy of the contingent liability account and institutional control account within the Low-level Radioactive Waste Trust Fund established in section forty-one; based on the annual report of the environmental monitoring program, issued pursuant to section thirty-six; a summary of procedures used to monitor each facility, the principal findings made concerning the facility and a detailed account of any release at the facility of radioactive or toxic materials into the workplace or the environment, including the measures taken to contain or remedy such release; and the facility closure plan prepared pursuant to regulations adopted under section sixteen;

(8) a review and analysis of the adequacy of available insurance protection for low-level radioactive waste management activities against personal injury and property damage, including third-party liability insurance;

(9) a review and analysis of the effectiveness and feasibility of, and the development of recommendations for, encouraging or requiring minimization of the volume, radioactivity, toxicity, or other characteristics of low-level radioactive waste; and

(10) interim and emergency storage plans to go into effect whenever it appears that no facility is or will be available to accept low-level radioactive waste generated within the commonwealth. Such plans may include contractual agreements with facilities located outside the commonwealth. Notwithstanding any provision of section sixteen, if such plans include the development of an interim or emergency storage facility, the board or its designee may apply for a facility license in accordance with the provisions of section thirty-one and, upon its issuance, may construct and operate a facility to accept low-level

radioactive waste for interim or emergency storage; provided, however, that no such facility may be constructed unless the department of public health has determined that the environmental monitoring program required in section thirty-six has yielded representative baseline data; and provided, further, that the board shall specify in its interim and emergency storage plans the maximum length of time during which such a facility may be utilized.

Added by St.1987, c. 549, § 5. Amended by St.1988, c. 199, § 22.

Historical and Statutory Notes

1987 Legislation

Section 8 of St.1987, c. 549, provides:

"Nothing in this act shall prohibit the department of public health from issuing a renewal license to any person lawfully holding a license to accept waste for treatment, storage or disposal as of the effective date of this act and any such person may apply to said department for an amendment of the terms and conditions of such license if the application for such amendment has been determined by the low-level radioactive waste management board to be consistent with the management plan adopted pursuant to section twelve of chapter one hundred and eleven H of the General Laws."

1988 Legislation

St.1988, c. 199, § 22, an emergency act, approved July 26, 1988, in cl. (1) of par. (b), substituted "toxicity and radioactive half-life" for "toxicity an radioactive half-life", and deleted "which" following "classes of low-level radioactive waste".

§ 13. Low-level radioactive waste source minimization, volume minimization and storage for decay by generators program; establishment

The department of public health, after consultation with the board, shall establish a program for low-level radioactive waste source minimization, volume minimization and storage for decay by generators. Said department shall adopt regulations necessary to implement such program consistent with the protection of public health, safety and the environment and with the promotion of responsible research and innovation. Such regulations shall require generators to avoid unnecessary contamination of items during the use of radioactive materials; to segregate radioactive waste from non-radioactive trash; and to prepare and implement plans for the utilization of all appropriate source minimization, volume minimization and storage for decay methods.

Added by St.1987, c. 549, § 5.

§ 14. Site selection criteria and application guidelines; adoption of regulations

(a) The department of environmental protection shall adopt regulations establishing criteria for the selection of any superior site, guidelines for their application, procedures for the conduct of site selection and plans for the creation within said department of a statewide resource center for the continued collection of data pertaining to site selection. Such regulations shall, at a minimum, be compatible with the federal regulatory program established pursuant to the Atomic Energy Act, 42 USC section 2071 et.seq. The primary consideration in adopting such regulations shall be the protection of public health, safety and the environment.

(b) The site selection criteria and application guidelines shall ensure, at a minimum, that any superior site satisfies the following site suitability requirements.

(1) sites shall be capable of being characterized, modeled, and monitored;

(2) sites shall be well drained and free of areas of flooding or frequent ponding, waste management areas shall be outside any one-hundred-year flood plain, coastal high-hazard area, or wetland;

(3) upstream drainage areas shall be minimized to decrease the amount of run-off which could erode or inundate the waste management area;

(4) sites shall provide sufficient depth to the water table so that groundwater intrusion, perennial or otherwise, into the waste will not occur;

(5) the hydrogeologic unit used for waste management shall not discharge groundwater to the surface within the site;

(6) waste management area shall be located so that tectonic processes in the vicinity, such as faulting, folding, seismic activity or volcanism, will not occur which will significantly effect the ability of the site to meet any performance objectives adopted by the department of public health under section sixteen, or preclude adequate modeling and prediction of long-term impacts;

(7) waste management area shall be located so that surface geologic processes in the vicinity, such as mass wasting, erosion, slumping, landsliding, or weathering will not occur which will significantly affect the ability of the site to meet any performance objectives adopted by the department of public health under section sixteen, or preclude adequate modeling and prediction of long-term impacts;

(8) waste management areas shall be located so that nearby activities will not adversely affect the ability of the site to meet any performance objectives adopted by the department of public health under section sixteen, or significantly impair the environmental monitoring program;

(9) sites shall be located in areas with no known economically recoverable resources which, if exploited, would adversely affect the ability of the site to meet any performance objectives adopted by the department of public health under section sixteen, or significantly impair the environmental monitoring program;

(10) sites shall be located outside of, and so as not to adversely affect, the recharge zones of existing or future drinking water source aquifers;

(11) sites shall have sufficient land available to provide for the waste volume and a reasonable buffer around the waste management area;

(12) sites shall be located so as not to adversely affect any national park, monument, lake shore, habitat of endangered species, or area protected by the Wilderness Act, 16 USC sections 1131–1136, the Wild and Scenic Rivers Act, 16 USC sections 1271–1287, and the Fish and Wildlife Coordination Act, 16 USC sections 661–666C; or the National Historic Preservation Act, 16 USC sections 470–470m; and

(13) sites shall be located away from any structure or area in which are regularly found persons who, because of their age or physical characteristics, are likely to be at significantly higher than normal risk of adverse health effects if exposed to the release of radioactive or associated toxic materials.

(c) The procedures for the conduct of site selection shall include a quality assurance program designed to ensure data reliability, validity, traceability, and retrievability, as well as completeness and technical adequacy, for use in making any site selection decisions or subsequent licensing determination.

(d) The application of the site selection criteria adopted pursuant to this section shall not be subject to waiver by the department of environmental protection or the board.

Added by St.1987, c. 549, § 5. Amended by St.1990, c. 177, §§ 202, 203.

Historical and Statutory Notes

1990 Legislation

St.1990, c. 177, § 202, an emergency act, approved Aug. 7, 1990, in par. (a), in the first sentence, substituted "protection" for "quality engineering".

Section 203 of St.1990, c. 177, in par. (d), substituted "protection" for "quality engineering".

§ 15. Selection of operators; adoption of regulations

The board shall adopt regulations governing the selection of operators. Such regulations shall include financial, technical and management criteria and shall establish procedures adequate to determine that the operator possesses sufficient reliability, expertise, and competence to operate a facility so as to protect public health and the environment. Such determination shall be based, in part, on information submitted by

applicants, in response to any request for proposals issued pursuant to section twenty-two, including:

(a) organizational information for the applicant and any proposed subcontractors detailing their legal structure, ownership and control and operational experience, and the background and qualifications of all officers, directors, partners and principal owners of each such firm and of the key personnel to be utilized in the performance of any contract with the board, and a description of the locations and operating experiences of existing or former operations of such persons; the history of compliance with, and any violations of federal, state or local requirements by such persons in any jurisdiction in which they or any of them have done business, and any felony convictions of such persons;

(b) a financial disclosure statement describing the applicant's financial resources and proposed revenue plans and demonstrating that the applicant either possesses the necessary funds or has reasonable assurance of obtaining the necessary funds to cover the estimated costs of development and operation of a facility and will have sufficient funds available to carry out facility closure and post-closure observation and maintenance; and

(c) a preliminary facility development, operation, closure, post-closure observation and maintenance and institutional control plan including a description of the proposed technology or technologies to be utilized, and of the applicant's staffing plans and personnel training program, safety and recordkeeping procedures, and emergency response plans.

Added by St.1987, c. 549, § 5. Amended by St.1988, c. 199, § 23.

Historical and Statutory Notes

1988 Legislation

St.1988, c. 199, § 23, an emergency act, approved July 26, 1988, in cl. (b), substituted "proposed" for "propose".

§ 16. Licensing, development, operation, closure, post-closure observation and maintenance, and institutional control of facilities; adoption of regulations

(a) The department of public health shall adopt regulations for the licensing, development, operation, closure, post-closure observation and maintenance, and institutional control of facilities in accordance with the procedure established in this section. Such regulations shall, at a minimum, be compatible with the federal regulatory program established pursuant to the Atomic Energy Act, 42 USC section 2071 et seq., and shall include procedures for license application and for setting a license decision schedule pursuant to section thirty-one; environmental and human exposure performance objectives, financial assurances and licensing requirements for facility construction; facility opening; low-level radioactive waste acceptance and inspection, storage, treatment and disposal; site maintenance; site safety, environmental monitoring and radiation and contamination control; facility security, recordkeeping and reporting; and quality control and training support; provided, however, that any disposal method utilized at a facility shall permit retrieval and monitoring of the waste, and provided further that shallow land burial shall be prohibited. Regulations governing low-level radioactive waste which is also hazardous waste as defined in section two of chapter twenty-one C, shall require an equivalent level of environmental protection as that required by said chapter and such regulations adopted thereunder; provided, however, that no low-level radioactive waste facility licensed pursuant to this chapter shall be subject to the provisions of chapter twenty-one D. Such regulations shall further require the operator to prepare, maintain and update a facility closure plan throughout the period of facility development and operation.

(b) The department of public health shall not issue a license pursuant to any regulation adopted under this section, authorizing any person to dispose of low-level radioactive waste or to accept waste from any other person for treatment or storage, unless the person making application for such license had been designated as an operator in

accordance with the procedures established pursuant to sections twenty-two and twenty-seven. The department of public health shall not issue a license pursuant to any regulation adopted under this section unless the applicant had obtained all other permits and licenses required by law in order to commence construction of a facility; provided, however, that no community may prohibit, or require any license, permit, approval or condition for the construction, operation, closure, post-closure observation and maintenance or institutional control of a facility.

(c) Together with any draft regulations to be adopted under this section, which are issued for public review and comment, the department of public health shall issue a statement of any major alternative regulatory approaches and performance objectives considered but not proposed, and the reasons for the approach chosen and a description of: (1) the significant public health, environmental, social and economic impact of current low-level radioactive waste management practices and regulatory programs; (2) such impacts as are likely to result from the adoption of said department's proposal and from major alternative regulatory approaches considered by said department; and (3) such impacts as are likely to result from improper packaging, transportation incidents, improper design or operation of a facility, natural disaster, or inadvertent or purposeful intrusion into the facility.

Added by St.1987, c. 549, § 5.

§ 17. Initiation of site selection process; board vote; conditions

(a) The board shall initiate the site selection process established in sections eighteen to twenty-three, inclusive, if it determines, by a two-thirds vote of its members, that it is necessary and appropriate to proceed with site selection. Such vote may be taken only if:

(1) the board has adopted a low-level radioactive waste management plan under section twelve, incorporating a finding that there is a requirement for additional facility capacity to meet present needs or needs anticipated to arise within the next decade;

(2) the department of public health has adopted regulations under section thirteen necessary to implement a program for source minimization, volume minimization and storage for decay by generators;

(3) the department of environmental protection has adopted, under section fourteen, criteria for selection of any superior site for the development and operation of a low-level radioactive waste management facility, guidelines for their application, and procedures for implementing the site selection process;

(4) the board has adopted regulations, under section fifteen, for the selection of operators; and

(5) the department of public health has adopted regulations, under section sixteen, for the licensing development, operation, closure, post-closure observation and maintenance and institutional control of a facility.

(b) No fewer than twenty-one days prior to a vote to initiate site selection pursuant to this section, the board shall issue a notice, satisfying the requirements of section two of chapter thirty A, of its intent to conduct such vote.

(c) Upon voting to initiate site selection, the board shall notify the chief executive officer of each community of the commencement of the site selection process, explaining in detail the site selection criteria, guidelines for their application and procedures for implementation of site selection, and offering the resources of the board and the public participation coordinator to assist communities in participating in the site selection process.

Added by St.1987, c. 549, § 5. Amended by St.1990, c. 177, § 204.

Historical and Statutory Notes

1990 Legislation

St.1990, c. 177, § 204, an emergency act, approved Aug. 7, 1990, in par. (a), in cl. (3), substituted "protection" for "quality engineering".

§ 18. Phase II of the Low-Level Radioactive Waste Management Act; implementation for site selection process

The selection of any superior site shall be conducted in accordance with sections nineteen to twenty-four, inclusive, which shall be known and may be cited as "Phase II of the Low-Level Radioactive Waste Management Act," and in accordance with the regulations adopted under section fourteen. The provisions of such sections and regulations shall be implemented so as to ensure an open and fair process for selecting a superior site for any facility determined to be needed pursuant to Phase I of the Low-Level Radioactive Waste Management Act and for certifying applicants who satisfy the regulatory criteria adopted pursuant to said Phase I.

Added by St.1987, c. 549, § 5.

§ 19. Site selection process; procedures

(a) The site selection process conducted pursuant to sections twenty and twenty-three shall be in accordance with the procedures set forth in this section. The recommendations of the public participation coordinator, made pursuant to section six, shall be implemented to the extent feasible in order to ensure appropriate public participation in the site selection process; to ensure that adequate information concerning the site selection process is available; to facilitate the conduct of public meetings and other opportunities for public review and comment; and to ensure that public concerns are identified and addressed throughout the site selection process.

(b) In accordance with the regulations adopted under section four, the board shall retain such consultants as it determines are necessary to complete the site selection process.

(c) Each notice required by section twenty or twenty-three to be given to the chief executive officer of a community shall, at a minimum, explain in detail all actions taken pursuant to sections eleven to seventeen, inclusive, and those actions completed pursuant to section twenty or twenty-three, as well as the remaining actions to be undertaken pursuant to section twenty, twenty-three or twenty-four, and offer the resources of the board and the public participation coordinator to assist communities in participation in the site selection process.

Added by St.1987, c. 549, § 5.

§ 20. Site selection process; issuance of required reports; public meetings; acquisition of property interest in candidate sites

(a) The board shall issue a statewide mapping and screening report using existing data and analysis collected by the statewide resource center established pursuant to section fourteen or obtained by the board as of the date of its vote to initiate site selection. Such report shall identify, and exclude from further consideration in the site selection process, those areas of the commonwealth that are obviously unable to satisfy the site selection criteria adopted by the department of environmental protection under said section fourteen.

(b) After the issuance of the statewide mapping and screening report, the board shall issue a report identifying possible locations, which are likely to contain one or more candidate sites. The report shall describe the procedures used to identify such possible locations and establish that such procedures conform to the requirements of the regulations adopted by the department of environmental protection under section fourteen. Such possible locations shall include all available lands in the commonwealth which, on the

basis of such information as is obtained by the board through its own investigations, appear to satisfy the site selection criteria adopted under said section fourteen. The board shall publicize the availability of such report for public review and comment, and shall provide a notice, satisfying the requirements of section nineteen to the chief executive officer of each community in which is located a possible location identified in the report. Within forty-five days of the issuance of such report, the board shall conduct at least one public meeting on the report in the vicinity of each possible location identified in the report at times and locations to be determined after consultation with the public participation coordinator and shall accept written comments thereon. The board shall consider and evaluate all comments and statements made at a public meeting or submitted in writing.

(c) Within ten months of the board vote, pursuant to section seventeen, to initiate the site selection process, the board shall issue a draft candidate site identification report. Such report shall identify at least two, but not more than five, candidate sites which the board considers best able to satisfy the site selection criteria adopted by the department of environmental protection under section fourteen, potentially licensable, capable of being developed, and otherwise appropriate for detailed site characterization pursuant to section twenty-three. Such report shall also include:

(1) a report of the results of a preliminary characterization of the meteorology, surface and groundwater, geology, tectonics, geomechanics, air quality, ecology, land use, cultural resources and social and economic characteristics of each such possible location;

(2) a description of the procedures used to identify the candidate sites based on such preliminary characterization; and

(3) draft plans for detailed site characterization of each candidate site pursuant to section twenty-three.

(d) The preliminary characterization required pursuant to this section shall be conducted, to the extent feasible, so as not to interfere with the quiet enjoyment of private property; provided, however, that, whenever the board deems it necessary to make surveys, soundings, drillings or examinations to obtain information for, or to expedite the preliminary characterization, its authorized agents or employees may, after due notice by registered or certified mail, enter upon any lands, waters and premises, not including buildings, in the commonwealth for the purposes of making surveys, soundings, drillings and examinations as the board may deem necessary or convenient, and such entry shall not be deemed a trespass. The board shall make reimbursement for any injury or actual damage resulting to such lands, water and premises caused by any act of its authorized agents or employees, and the board shall, so far as possible, restore such lands to the same condition as prior to the making of such surveys, soundings, drillings or examinations.

(e) Upon the issuance of the draft candidate site identification report, the board shall transmit a copy of the draft report to the secretary of the executive office of environmental affairs; and widely publicize its availability for public review and comment; and the board and the deputy commissioner of the division of capital planning and operation shall jointly provide a notice satisfying the requirements of section nineteen of this chapter and section forty I of chapter seven, to all persons entitled under said section forty I of chapter seven to receive such notices and to the chief executive officer of each community in which is located all or part of a candidate site identified in such draft report. The board shall request each such chief executive officer to take appropriate action to establish a community supervisory committee for such community in accordance with section twenty-one.

(f) No person owning property identified in the draft candidate site identification report shall take any action or cause to have any action taken with respect to such property prior to the acceptance or amendment of such report by the board pursuant to this section which has the effect of interfering with or rendering more difficult or expensive the conduct of detailed site characterization of the property or the acquisition of a property interest therein pursuant to this section or section twenty-four.

(g) Within sixty days of the issuance of the draft report, the board shall conduct at least one public meeting on the report in each community in which is located all or part of a candidate site identified in the draft report, at times to be determined after consultation with the public participation coordinator. Such public meeting shall be deemed to satisfy the public hearing requirements of section forty I of chapter seven. The board shall accept written comments on the report submitted within sixty days of the public notice of its availability. Prior to its acceptance of the draft report, the board shall consider and evaluate all comments and statements made at a public meeting or submitted in writing.

(h) Upon receipt of the draft report, the secretary of the executive office of environmental affairs shall implement the public review and comment procedures established pursuant to section sixty-two C of chapter thirty; provided, however, that the review period established in such section shall not extend beyond the final date for acceptance of written comments by the board pursuant to this section. Within sixty days of the issuance of the draft report, said secretary shall issue a statement evaluating its technical adequacy and conformance with the regulations adopted under section fourteen. The said secretary shall transmit a copy of such statement to the board.

(i) No less than seventy-five days and no more than ninety days after the issuance of the draft report, the board shall conduct a vote to determine whether to accept the report and to proceed with detailed site characterization of the candidate sites identified therein, or amend the report and proceed with detailed site characterization of the candidate site identified in the report as amended. Such a vote shall be based on the technical adequacy of the report and its conformance with the regulations adopted under section fourteen. If the board fails to accept or amend the report, the report shall be set aside and the procedures established in this section shall be repeated; provided, however, that the board shall issue its revised draft report within four months of the expiration of the time for it to accept or amend the previous candidate site identification report.

(j) Upon the board's vote to proceed with detailed site characterization, the deputy commissioner of the division of capital planning and operations shall, on behalf of the board, take appropriate action to acquire, by purchase or taking, pursuant to chapter seventy-nine, a determinable property interest in each candidate site identified in the candidate site identification report as accepted or amended by the board, or, in the case of real property of the commonwealth, to transfer the control and use of such property to the board. Acquisition or transfer of each such property interest shall be subject to the requirements of sections forty E to forty M, inclusive, of chapter seven; provided, however, that each candidate site shall be deemed to possess unique qualities for the purpose of section forty II of chapter seven. Such property interest shall be adequate to permit the conduct of detailed site characterization of the property, and to restrict the right to develop the property until a facility license is issued, pursuant to section thirty-one, to operate a facility at one of the candidate sites identified in the candidate site identification report as accepted or modified by the board.

Added by St.1987, c. 549, § 5. Amended by St.1990, c. 177, §§ 205 to 207.

Historical and Statutory Notes

1990 Legislation

St.1990, c. 177, § 205, an emergency act, approved Aug. 7, 1990, in par. (a), in the second sentence, substituted "protection" for "quality engineering".

Section 206 of St.1990, c. 177, in par. (b), in the second sentence, substituted "protection" for "quality engineering".

Section 207 of St.1990, c. 177, in par. (c), in the second sentence, substituted "protection" for "quality engineering".

§ 21. Community supervisory committees; establishment

(a) Upon issuance of the draft candidate site identification report, the board shall request the chief executive officer of each community in which is located all or part of a candidate site identified in such draft report to take appropriate action to establish a community supervisory committee for such community. Each community supervisory

committee shall be composed of the chief executive officer or his designee, who shall serve as chairperson; the chairperson of the conservation commission or his designee; the chairperson of the board of health or his designee; the chairperson of the planning board or his designee; and three residents of the community nominated by the chief executive officer and approved by a majority vote of the city council or board of selectmen, who shall serve at the pleasure of the chief executive officer.

(b) If the chief executive officer of such community fails to take appropriate action to establish a community supervisory committee within forty-five days of the issuance of the draft candidate site identification report, the board shall designate a committee to assume the responsibilities of the community supervisory committee for such community until such community supervisory committee is established.

(c) The powers and duties of each community supervisory committee shall be:

(1) upon the designation of candidate sites pursuant to section twenty, to represent the best interests of the candidate site community in the site selection process established pursuant to sections twenty, twenty-three and twenty-four;

(2) upon selection of any superior site located within the community, to represent the best interests of the site community in the environmental review of, and licensing proceedings for the facility to be developed at such superior site and in the review and monitoring of facility operations; and

(3) to designate an operator and technology pursuant to section twenty-seven; and

(4) to receive and expend such technical assistance and planning funds as may be provided pursuant to this section.

(d) The board shall, in accordance with the regulations adopted under section four, provide sufficient funds to each community supervisory committee to enable it to acquire administrative and clerical personnel and to retain consultants necessary to exercise the powers and duties established in this section.

(e) Upon the expiration of thirty days after the selection of any superior site or, if a petition for an adjudicatory proceeding has been filed pursuant to section twenty-four, upon a final decision of the commissioner of the department of environmental protection approving the site selection, no further funds shall be provided, pursuant to this section, to community supervisory committees in communities other than a site community. Upon the execution of a comprehensive operating contract pursuant to section thirty-three, no further funds shall be provided to community supervisory committees in site communities pursuant to this section.

Added by St.1987, c. 549, § 5. Amended by St.1990, c. 177, § 208.

Historical and Statutory Notes

1990 Legislation

St.1990, c. 177, § 208, an emergency act, approved Aug. 7, 1990, in par. (e), in the first sentence, substituted "protection" for "quality engineering".

§ 22. Requests for proposals for development, operation and closure of a facility; investigation and certification of applicants; contract

(a) Within sixty days of a vote, pursuant to section seventeen, to initiate site selection, and after consultation with the deputy commissioner of the division of capital planning and operations the board shall issue a request for proposals for the development, operation, closure and post-closure observation and maintenance of a facility. The request for proposals shall conform to the regulations adopted under section fifteen, and shall include the most recent management plan adopted by the board under section twelve and a statement of procedures to be followed in responding to the request for proposals. The request for proposals shall require responses to be submitted by applicants within one hundred twenty days after its issuance. Each applicant shall be required to specify the terms under which it will participate in an advisory board that will assist in the planning and implementation of detailed site characterization pursuant to section twenty-

four, and pay the board a fee of not less than ten thousand dollars at the time it submits its response to the request for proposals. Such fee shall be refunded only if the board fails to select a superior site, pursuant to section twenty-three, from among the candidate sites identified pursuant to section twenty.

(b) Within sixty days of the final date for submission of responses to the request for proposals, the attorney general shall prepare an investigative report to the board and the community supervisory committees, on each applicant and its officers, directors, partners, principal owners, key personnel and proposed subcontractors, describing their record of compliance with environmental and related laws, regulations, permits and licenses. Each applicant shall annually by March first, submit to the state ethics commission and the inspector general, a report listing each expenditure made during the previous calendar year by an official, employee or representative of the firm, including consultants or subcontractors, to or for the benefit of an official, employee, or representative, including consultants, of the board, the department of public health, the department of environmental protection, the division of capital planning and operations or any community supervisory committee. An officer of the firm shall certify the report as complete and accurate under pains and penalties of perjury. The state ethics commission, upon finding that there has been a violation of the reporting requirement set forth in this section, may issue an order requiring the violator to pay a civil penalty of not more than one thousand dollars for each day of violation and may file a civil action in superior court to enforce such order.

(c) Upon the issuance of the draft candidate site identification report pursuant to section twenty, and after consultation with the deputy commissioner of the division of capital planning and operations, the board shall certify those applicants who satisfy the financial, technical and management criteria adopted under section fifteen. Such certification shall be accompanied by a report including a justification for the certifications made. Such report shall be distributed to each community supervisory committee, the applicants and all others making a timely request. No applicant who fails to be certified pursuant to this section shall be required to submit a report to the state ethics commission and the inspector general, in accordance with this section, for any year after the year during which the certification of applicants is made.

(d) Within ninety days of the issuance of the draft candidate site identification report pursuant to section twenty, the board shall execute a contract with each certified applicant under which the applicant shall participate in an advisory board that will assist in the planning and implementation of detailed site characterization of the candidate sites identified pursuant to said section twenty.

Added by St.1987, c. 549, § 5. Amended by St.1990, c. 177, § 209.

Historical and Statutory Notes

1990 Legislation

St.1990, c. 177, § 209, an emergency act, approved Aug. 7, 1990, in par. (b), in the second sentence, substituted "protection" for "quality engineering".

§ 23. Detailed site characterization plan for candidate sites; public review and comment; selection of superior site

(a) Each community supervisory committee shall assist the board in developing a detailed site characterization plan for a candidate site located within the community and participate throughout the implementation of such detailed site characterization plan. Appropriate board officials and consultants shall meet monthly with each community supervisory committee. Each community supervisory committee shall be kept informed of the progress of the detailed site characterization; be furnished copies of all data, reports and memoranda pertaining to said detailed site characterization including raw data, draft reports and memoranda; and given reasonable opportunity to review and comment upon all work performed.

(b) Within thirty days of the acceptance of the candidate site identification report pursuant to section twenty, the board and the community supervisory committee shall

jointly conduct a public meeting in each candidate site community to discuss the draft plan for the detailed site characterization of the candidate site located within such community. The detailed site characterization plan adopted by the board shall include investigations and tests, both in the field and in the laboratory, which shall be conducted so as to demonstrate whether the site complies with the site selection criteria adopted under section fourteen; to provide information necessary for licensing of any facility at the site pursuant to section thirty-one, including an evaluation of the ability of the site characteristics to contribute to isolation of waste, data necessary for the proposed design of such a facility, an identification of potential interactions between the site characteristics and any low-level radioactive waste or waste containers located at the site to establish data collection points and baseline data suitable for use in an environmental monitoring program adopted pursuant to section thirty-six; and to identify, for inclusion in any environmental impact report prepared pursuant to section thirty, potential environmental impacts resulting from the development, operation, closure, post-closure observation and maintenance or institutional control of a facility at the site. Prior to its adoption of the final plan, the board shall consider and evaluate all comments made at a public meeting or in writing.

(c) Within one year and two months of the acceptance of the candidate site identification report pursuant to section twenty, the board shall issue a draft report of the detailed site characterization of each candidate site, and shall transmit a copy of such report to the secretary of the executive office of environmental affairs and the community supervisory committee. The draft report shall described the procedures used to characterize each candidate site and establish that such procedures fully conform to the requirements of the regulations adopted under section fourteen.

(d) Upon issuance of the draft detailed site characterization report, the board shall widely publicize its availability for public review and comment, and the deputy commissioner of the division of capital planning and operations shall issue a notice, satisfying the requirements of section forty I of chapter seven, to all persons entitled thereby to review such notice. Within sixty days of the issuance of such report, the board shall conduct at least one public meeting on the report, in each candidate site community, at times to be determined after consultation with the public participation coordinator. Such public meeting shall be deemed to satisfy the public hearing requirements of section forty I of chapter seven. The board shall accept written comments on the report submitted by the community supervisory committee or any other interested person within sixty days of the public notice of its availability.

(e) Upon receipt of the draft detailed site characterization report, the secretary of the executive office of environmental affairs shall implement the public review and comment procedures established pursuant to section sixty-two C of chapter thirty; provided, however, that the review period established in such section shall not extend beyond the final date for acceptance of written comments by the board pursuant to this section. Within seventy-five days of the issuance of the report, said secretary shall issue a statement evaluating its technical adequacy and conformance with the regulations adopted under section fourteen. The said secretary shall transmit a copy of such statement to the board and the community supervisory committee.

(f) No sooner than seventy-five days and no later than ninety days after the issuance of the draft detailed site characterization report, the board shall conduct a vote to determine whether to accept or amend the report. Such a vote shall be based on the technical adequacy of the report and its conformance with the regulations adopted pursuant to section fourteen. Prior to its acceptance of the report, the board shall consider and evaluate all comments made at a public meeting or submitted in writing. If the board fails to accept or amend the detailed site characterization report, the report shall be set aside, and the procedures established in this section shall be repeated; provided, however, that the board shall meet with each community supervisory committee to discuss the draft plan for implementing the revised detailed site characterization within thirty days of the expiration of the time for the board to accept or modify the detailed site characterization report; and provided, further, that the board shall issue its revised detailed site characterization report within one year and two months of the expiration date of the time for the board to accept or amend the prior detailed site characterization report.

(g) Upon voting to accept or modify a detailed site characterization report, the board may select any superior site by a two-thirds vote of its members. Upon such vote, the deputy commissioner of the division of capital planning and operations shall, on behalf of the board, take appropriate action to acquire, by purchase or taking, pursuant to chapter seventy-nine, a fee simple interest in the superior site, together with such other land, easements, rights-of-way or other property interests necessary to construct and operate a facility thereon and to conduct an environmental monitoring program pursuant to section thirty-six, or, in the case of real property of the commonwealth, to transfer the control and use of such property to the board. Such acquisition or transfer shall be subject to the requirements of sections forty E to forty M, inclusive, of chapter seven; provided, however, that the superior site shall be deemed to possess unique qualities for the purposes of section forty H of said chapter seven. Upon the acquisition of such interest, each site community, during the period prior to the issuance of a facility license, shall be entitled to receive an amount in lieu of local property taxes in accordance with section seventeen of chapter fifty-eight. No facility developed at a superior site selected pursuant to this section shall be subject to the department of environmental protection site assignment pursuant to section one hundred and fifty B of chapter one hundred and eleven.

Added by St.1987, c. 549, § 5. Amended by St.1990, c. 177, § 210.

Historical and Statutory Notes

1990 Legislation

St.1990, c. 177, § 210, an emergency act, approved Aug. 7, 1990, in par. (g), in the fifth sentence, substituted "protection" for "quality engineering".

§ 24. Petition by aggrieved person; adjudicatory proceeding

(a) Upon petition by any person aggrieved by an action taken pursuant to sections nineteen, twenty, or twenty-three, made within thirty days after selection of a superior site pursuant to section twenty-three, the commissioner of the department of environmental protection shall commence an adjudicatory proceeding concerning the selection of the site. Such adjudicatory proceeding shall commence within sixty days of the filing of said petition and shall be conducted in compliance with the requirements of section eleven of chapter thirty A.

(b) In addition to the petitioner, the board and the site and neighboring communities shall be parties to the adjudicatory proceeding. Other aggrieved persons may intervene in accordance with the provisions of chapter thirty A.

(c) Within thirty days after the close of the adjudicatory proceeding, the commissioner of said department shall issue a final decision approving or disapproving the selection of the superior site. The site selection shall be approved if said commissioner finds, based on substantial evidence presented during the adjudicatory proceeding, that the site satisfies the site selection criteria adopted under section fourteen.

(d) The reasonable expenses of participation in the adjudicatory proceeding by site and neighboring communities, including attorney's fees, shall be reimbursed by the board in accordance with an order, specifying the amount and time for reimbursement, issued by the commissioner of the department of environmental protection at the time of the final decision.

(e) Any person aggrieved by a decision of said commissioner pursuant to this section may seek judicial review thereof in the supreme judicial court in accordance with the standards provided for judicial review in section fourteen of chapter thirty A.

Added by St.1987, c. 549, § 5. Amended by St.1990, c. 177, §§ 211, 212.

Historical and Statutory Notes

1990 Legislation

St.1990, c. 177, § 211, an emergency act, approved Aug. 7, 1990, in par. (a), in the first sentence, substituted "protection" for "quality engineering".

Section 212 of St.1990, c. 177, in par. (d), substituted "protection" for "quality engineering".

§ 25. Phase III of the Low-Level Waste Management Act; selection of operator and technology

The selection of an operator and technology or technologies to be utilized at a facility to be developed at any superior site shall be, conducted in accordance with sections twenty-six to twenty-eight, inclusive, which shall be known and be cited as "Phase III of the Low-Level Waste Management Act", and in accordance with the regulations adopted under section fifteen. The provision of said sections twenty-six to twenty-eight, inclusive, and regulations shall be implemented so as to permit any site community to select the operator and technology or technologies that best ensure proper facility operation in order to protect public health, safety and the environment.

Added by St.1987, c. 549, § 5.

§ 26. Community supervisory committee representatives, appointment; site community field offices, establishment

(a) Upon the expiration of thirty days after the selection of any superior site or, if a petition for an adjudicatory proceeding has been filed pursuant to section twenty-four, upon a final decision of the commissioner of the department of environmental protection approving the site selection, the board shall request the chief executive officer of each neighboring community to appoint a representative to the community supervisory committee of each site community. If the chief executive officer of a neighboring community fails to take such action within twenty-one days of receiving such request, the board shall make the appointment.

(b) Within sixty days of the selection of any superior site or, if a petition for an adjudicatory proceeding has been filed pursuant to section twenty-four, within thirty days of a final decision of the commissioner of the department of environmental protection approving the site selection, the board shall establish a field office within a site community outside the boundaries of the superior site.

Added by St.1987, c. 549, § 5. Amended by St.1990, c. 177, §§ 213, 214.

Historical and Statutory Notes

1990 Legislation

St.1990, c. 177, § 213, an emergency act, approved Aug. 7, 1990, in par. (a), in the first sentence, substituted "protection" for "quality engineering".

Section 214 of St.1990, c. 177, in par. (b), substituted "protection" for "quality engineering".

§ 27. Certified applicant interviews; selection of operator of superior site facility

(a) No sooner than eleven months and no more than one year and two months after the acceptance of the candidate site identification report pursuant to section twenty, the community supervisory committee of each candidate site community shall interview those certified applicants who indicate their willingness to develop and operate a facility at a candidate site located within such community, and shall meet with the board or the deputy commissioner of the division of capital planning and operations at the request of any of them to discuss any aspects of the certified applicants qualifications or responses to the request for proposals.

(b) Each certified applicant interview shall be given an opportunity to submit to the community supervisory committee of the site community a written response to any question or requests made of such applicant, including a description of any necessary changes in the development, operation, closure, post-closure observation and maintenance and institutional control plans proposed to be implemented at the superior site and such

other information that will allow the community supervisory committee to determine whether the applicant will be able to ensure proper facility operation in order to protect public health, safety and the environment and to serve the site and neighboring communities' interests, including any covenants proposed to be made by the applicant concerning transportation routing; access road construction; limitations on the hours or number of daily deliveries of low-level radioactive waste to the facility; the number of facility employees to be hired from among site, affected and neighboring community residents; and the amount of business to be contracted for with site, affected and neighboring community firms. Such written responses shall be submitted within sixty days of the selection of such superior site pursuant to section twenty-three.

(c) No fewer than sixty days and no more than ninety days after the selection of any superior site pursuant to section twenty-three, the community supervisory committee of the site community shall select, from among the certified applicants interviewed, the operator of the facility to be developed at such site; provided, however, that, if the candidate site is situated in more than one community, such selection shall be made by a majority vote of the members of the combined community supervisory committees of the site communities.

(d) If the community supervisory committee or committees fail to select an operator from among the certified applicants in accordance with this section, the board shall select such operator by a vote of its members.

(e) The selection of an operator pursuant to this section shall not be subject to the requirement of section forty-four A of chapter one hundred forty-nine.

(f) No certified applicant who fails to be selected as an operator pursuant to this section shall be required to submit a report to the state ethics commission and the inspector general, in accordance with section twenty-two, for any year after the year during which the operator is selected.

Added by St.1987, c. 549, § 5.

§ 28. Execution of development contract

(a) Within sixty days of the selection of the operator pursuant to section twenty-seven, the board shall execute a development contract under which such operator shall be obligated to fulfill all of the requirements of the facility approval process established in sections twenty-nine to thirty-four, inclusive, in accordance with the plan submitted by the operator pursuant to section twenty-seven or any revision thereof approved by the board, and specifying a bond to be posted in an amount to be determined by the board, payable to the board and conditioned on the faithful performance of the obligations, agreements and covenants specified in the development contract. The bond shall provide that, if the operator defaults on the development contract, it shall pay to the board all damages sustained as a result of the default. The deputy commissioner of the division of capital planning and operations shall assist the board in overseeing the operator's activities under the development contract and shall advise the board on the adequacy of such development activities. If no development contract is executed within sixty days of the designation of the operator or the required bond is not posted, the operator selection shall be set aside, and the procedures established in section twenty-seven shall be repeated in order to select a replacement operator; provided, however, that the community supervisory committee shall select such replacement operator within thirty days of the expiration of the time for the operator originally selected to execute the development contract or post the performance bond.

(b) Within thirty days of the execution of the development contract, the operator shall establish a field office within a site community outside the boundaries of the superior site.

Added by St.1987, c. 549, § 5.

§ 29. Phase IV of the Low-Level Radioactive Waste Management Act; facility approval and licensing

Facility approval and licensing shall be conducted in accordance with sections thirty to thirty-four, inclusive, which shall be known and be cited as "Phase IV of the Low-Level

Radioactive Waste Management Act", and in accordance with the regulations adopted under section sixteen. The provisions of such sections and regulations shall be implemented so as to ensure an open and fair process for carrying out the environmental review and licensing of any facility for which a site, operator and technology have been selected pursuant to Phase III of the Low-Level Radioactive Waste Management Act and to require a comprehensive operating contract setting forth the rights and responsibilities of the board and the operator with respect to such facility.

Added by St.1987, c. 549, § 5.

§ 30. Notice of intent to apply for facility license; environmental impact report

(a) Except as otherwise provided in this section, the development, operation, closure, post-closure observation and maintenance and institutional control of a facility at any superior site shall be subject to sections sixty-one to sixty-two H, inclusive, of chapter thirty. No action taken pursuant to sections ten to twenty-eight, inclusive, shall be deemed to be a project within the meaning of section sixty-two of chapter thirty.

(b) Upon execution of the development contract pursuant to section twenty-eight, the operator shall prepare a notification to the secretary of the executive office of environmental affairs of the operator's intent to apply for a facility license pursuant to section thirty-one and for such other permits, as defined in section sixty-two of chapter thirty, as may be required by law for the development or operation of a facility at the superior site. The contents of such notification shall substantially conform to the plans submitted by the operator pursuant to section twenty-seven or any revision thereof approved by the board. Upon approval of the contents of the notification by the board, after consultation with the community supervisory committee of each site community, the notification shall be filed with said secretary in accordance with the provisions of section sixty-two A of chapter thirty, and a copy thereof shall be transmitted to the department of public health.

(c) Notwithstanding any provision of section sixty-two A of chapter thirty to the contrary, an environmental impact report shall be required on the proposed development, operation, closure, post-closure observation and maintenance and institutional control of a facility at any superior site. The report shall identify each community which can be expected to experience significant impacts as a result of the location, development, operation, closure, post-closure observation and maintenance and institutional control of the facility. In making a determination of the scope of the reports pursuant to such section, the secretary of the executive office of environmental affairs may require an examination of only those candidate sites identified pursuant to section twenty as alternative sites for the facility.

(d) The development, operation, closure, post-closure observation and maintenance and institutional control of a facility at any superior site shall be considered a major and complicated project within the meaning of section sixty-two A of chapter thirty. In establishing a specific procedure for evaluation and review of the environmental impacts of the project, said secretary shall appoint a citizens advisory committee in accordance with regulations adopted pursuant to such section to perform the functions established thereunder. The citizens advisory committee shall be composed of the members of the community supervisory committee of each site community and not more than six additional members selected by said secretary.

(e) The public and agency review periods of thirty days for the notice of availability of any draft or final report established by section sixty-two C of chapter thirty shall each be extended for a period of thirty days. During periods for review of the draft environmental impact report, said secretary shall hold at least one public meeting on the report in each site community and additional public meetings in neighboring communities upon request by the chief executive officer of any such community.

(f) The final facility license decision of the department of public health pursuant to section thirty-one shall not be subject to the requirements of section sixty-two D of chapter thirty.

Added by St.1987, c. 549, § 5. Amended by St.1988, c. 199, § 24.

Historical and Statutory Notes

1988 Legislation

St.1988, c. 199, § 24, an emergency act, approved July 26, 1988, in the first sentence of par. (a), substituted "operation" for "operator".

§ 31. Facility license application; public comment period; preparation of draft license or draft denial; final decision

(a) Upon the filing with the secretary of the executive office of environmental affairs of a notification pursuant to section thirty of intent to apply for a facility license, the operator may file a facility license application with the department of public health in accordance with regulations adopted under section sixteen. The license application shall be determined to be complete when said department finds that all information required by such regulations has been submitted and any additional requirements established by regulation adopted under said section sixteen have been satisfied; provided, however, that nothing in this section shall prohibit said department from requiring an operator to submit additional information necessary to evaluate the application at any time prior to the final license decision. Said department may summarily deny a facility license if the operator fails or refuses to correct deficiencies in the application. Such summary denial shall be accompanied by an explanation of the reasons for the denial. For each complete application, said department shall set a decision schedule in accordance with its regulations adopted under said section sixteen setting forth the date by which it intends to prepare a draft license or draft denial; and to issue a final license decision. Said department shall adhere to such decision schedule unless it finds that an extension of the schedule, not to exceed ninety days, is necessary to protect the public health or the environment, in which case said department shall adhere to such decision schedule as extended, provided, however, that nothing in this section shall authorize said department to issue a final facility license decision prior to action by the secretary of the executive office of environmental affairs on the final environmental impact report prepared pursuant to section thirty of this chapter and section sixty-two C of chapter thirty.

(b) The public comment period on a facility license application shall commence upon the filing of the notification of intent to apply for a facility license pursuant to section thirty. The recommendations of the public participation coordinator, made pursuant to section six, shall be implemented to the extent feasible in order to ensure public participation in the facility licensing process; to ensure that adequate information concerning the facility licensing process is available; to facilitate the conduct of public meetings and other opportunities for public review and comment; and to ensure that public concerns are identified and addressed throughout the facility licensing process. The department of public health shall give notice of the commencement of the public comment period by mail to the applicant, the community supervisory committee of each site community and the board and by publication in accordance with regulations adopted pursuant to section sixty-two A of chapter thirty, in a daily or weekly newspaper of general circulation within each site and neighboring community, and by broadcasting on radio stations serving each such community. The public comment period shall continue for forty-five days after the issuance of a draft license or draft denial pursuant to this section; provided, however, that said department shall extend the public comment period if it issues a modified draft license, until forty-five days after the issuance of such a modified draft license. During the public comment period, any person may submit comments in writing on any aspect of the application or the draft license or draft denial; copies of all written comments and memoranda prepared or received by said department shall be made available to persons upon request; and said department shall conduct at least one public meeting on the license application and the draft license or draft denial within each site community and other public meetings in neighboring communities upon request by the chief executive officer of such community.

(c) For each complete facility license application reviewed pursuant to this section, the department of public health shall, after action by the secretary of the executive office of environmental affairs on a draft environmental impact report pursuant to section thirty of

this chapter and section sixty-two C of chapter thirty, prepare a draft license or draft denial. A draft license shall include facility design and performance specifications and all conditions required to operate the facility. A copy of the draft license or draft denial shall be sent to the operator, the community supervisory committee of each site community, the board and, upon request, to other interested persons, and shall be accompanied by an explanation of the reasons therefor and a description of the procedures to be followed in reaching a final license decision. Such description shall include the date on which the public comment period is to end; the dates and locations of scheduled public meetings on the draft license or draft denial, the procedures to be followed by persons wishing to participate in the process leading to the final license decision, and the name, address and telephone number of the person within said department to contact for additional information.

(d) A copy of the department of public health's final facility license decision shall be sent to the applicant, the community supervisory committee of each site community, the board, any person who submitted written comments during the public comment period and, upon request, to other interested persons. Such final decision shall be accompanied by a summary response to comments received during the public comment period and an explanation of the reasons for any difference between the draft license or denial and the final license decision.

Added by St.1987, c. 549, § 5.

§ 32. [Blank]

§ 33. Negotiation of comprehensive operating contract; contents

(a) Upon issuance of a facility license pursuant to section thirty-one, the board, after consultation with the community supervisory committee of each site community, and the operator shall negotiate a comprehensive operating contract setting forth, consistent with the management plan adopted under section twelve, the rights and responsibilities of each party with respect to the facility and specifying that site, affected and neighboring communities are third party beneficiaries. The board and the operator shall execute such contract upon the appropriation of funds necessary to ensure that the board can satisfy the community compensation responsibilities thereunder. Such contract shall specify the terms on which the superior site is to be leased to the operator, shall set forth design and performance specifications for the facility, shall establish the right of the board to supervise all aspects of the development, operation, closure and post-closure observation and maintenance of the facility, and shall set the condition that must be satisfied prior to transfer of the facility license pursuant to section forty-six. The deputy commissioner of the division of capital planning and operations shall assist the board in overseeing the development of the facility and shall advise the board on the adequacy of all development activities. The comprehensive operating contract shall also provide that the board may modify or terminate the contract if it determines that a change in the ownership or control, or in the directors or officers of the operator or a change in any of its principal subcontractors may adversely affect the safe development, operation, closure or post-closure observation and maintenance of the facility. In addition, the contract shall provide that:

(1) The operator shall abide by all covenants proposed to be made to each site, neighboring and affected community in the application filed pursuant to section twenty-two or in any written statements submitted pursuant to section twenty-seven.

(2) The board shall abide by any additional covenants undertaken for the benefit of site, affected or neighboring communities which it deems necessary and appropriate. Such covenants may include obligations to reimburse a community for road maintenance or reconstruction or other increased infrastructure costs resulting from siting, development or operation of a facility.

(3) The operator shall annually pay to each site community, during the period commencing with the issuance of a facility license, pursuant to section thirty-one and ending with the transfer of such license to the board pursuant to section forty-six, a sum equal to the amount due to such community in real property taxes, provided, however, upon the

transfer of the license from the operator to the board pursuant to section forty-six, each site community, during the period of institutional control, shall receive an amount in lieu of local property taxes in accordance with section seventeen of chapter fifty-eight.

(4) The operator shall annually pay to the site community during the period of the facility's operation, a sum equal to four per cent of the annual gross operating receipts of the facility; provided, however, that, except during the first calendar year of a facility's operation, if the facility accepts less than one hundred thousand cubic feet of low-level radioactive waste in any calendar year, the sum to be paid to the site community pursuant to this section shall not be less than two hundred forty thousand dollars; if the facility accepts one hundred thousand cubic feet or more, but less than two hundred thousand cubic feet, of low-level radioactive waste in any calendar year, the sum to be paid to the site community pursuant to this section shall not be less than three hundred twenty thousand dollars; and if the facility accepts two hundred thousand cubic feet or more of low-level radioactive waste in any calendar year, the sum to be paid to the site community pursuant to this section shall not be less than four hundred thousand dollars; during the first calendar year of a facility's operation, the minimum sum to be paid to the site community pursuant to this section shall be prorated in accordance with a schedule to be agreed upon by the operator and the board. In addition to any other amounts paid pursuant to this paragraph, the operator shall pay one hundred and fifty thousand dollars per year, pro rata, to the site community during the period commencing with the opening of the facility and ending five years after the issuance of a facility license. If a facility is located in more than one community, all amounts paid pursuant to this paragraph shall be divided among the site communities in accordance with the formula established pursuant to section thirty-four.

(5) The operator shall annually pay to the neighboring communities during the period of the facility's operation, a sum equal to one per cent of the annual gross operating receipts of the facility; provided, however, that, except during the first calendar year of a facility's operation, if the facility accepts less than one hundred thousand cubic feet of low-level radioactive waste in any calendar year, the sum to be paid to neighboring communities pursuant to this section shall not be less than sixty thousand dollars; if the facility accepts one hundred thousand cubic feet or more, but less than two hundred thousand cubic feet, of low-level radioactive waste in any calendar year, the sum to be paid to neighboring communities pursuant to this section shall not be less than eighty thousand dollars; and if the facility accepts two hundred thousand cubic feet or more of low-level radioactive waste in any calendar year, the sum to be paid to neighboring communities pursuant to this section shall not be less than one hundred thousand dollars; during the first calendar year of a facility's operation, the minimum sum to be paid to the site community pursuant to this section shall be provided in accordance with a schedule to be agreed upon by the operator and the board; and provided, further, that such sum shall be divided among such communities in accordance with formula established pursuant to section thirty-four.

(6) The operator shall collect a surcharge, established pursuant to section thirty-eight, for the Low-level Radioactive Waste Trust Fund, established in section forty-one, and shall promptly remit the amounts collected, together with any interest accrued thereon, to the state treasurer as treasurer of such Fund.

Added by St.1987, c. 549, § 5.

§ 34. Community compensation

Any community compensation to be provided for site communities pursuant to the comprehensive operating contract shall be divided among such communities in the proportion that each community's population residing within three miles of the facility bears to the total population of site communities within such area. The community compensation to be provided for neighboring communities pursuant to the comprehensive operating contract shall be divided among such communities in the proportion that each community's population residing within three miles of the facility bears to the total population of such communities within such area; provided, however, that if the facility

has no neighboring communities, such community compensation shall be divided among the site communities in accordance with the formula established in this section.

Added by St.1987, c. 549, § 5.

§ 35. Phase V of the Low-Level Radioactive Waste Management Act; facility development, operation, and closure

Facility development, operation, closure, and post-closure observation and maintenance shall be conducted in accordance with sections thirty-six to forty-four, inclusive, shall be known and be cited as "Phase V of the Low-Level Radioactive Waste Management Act", and in accordance with the regulations adopted by the department of public health under section sixteen. The provisions of such sections and regulations shall be implemented so as to provide for the safe and orderly development, operation, closure and post-closure observation and maintenance of any facility licensed pursuant to "Phase IV of the Low-Level Radioactive Waste Management Act".

Added by St.1987, c. 549, § 5.

§ 36. Comprehensive environmental monitoring program; establishment

(a) Within thirty days of the issuance of a facility license pursuant to section thirty-one; the department of public health shall, after consultation with the department of environmental protection and the board of health of each site community, establish a comprehensive environmental monitoring program at the facility site. Such program shall employ the best available monitoring technology and shall provide, to the maximum extent feasible, for the participation of officials and citizens of each site community and the training of such persons to facilitate their participation. The program shall be designed to establish baseline environmental data on the site; to determine compliance with applicable regulations, with conditions of the facility license and with terms of the comprehensive operating contract; to provide early warning of the magnitude and extent of any radionuclide migration; and to provide reliable environmental data throughout development, operation, closure, post-closure operation and maintenance and institution control of the facility. The program shall collect and analyze data concerning standing and running surface water and drainage; groundwater samples from offsite, site boundary and waste management area wells; soil and vegetation samples; atmospheric samples; and radiation measurements offsite, at the site boundary and in the waste management area. The board of health of each site community shall be entitled to obtain portions of the samples collected pursuant to the program for independent analysis by a laboratory certified to conduct such analyses by the United States Environmental Protection Agency.

(b) The operator shall, according to applicable regulations and conditions of the facility license, cooperate with the environmental monitoring program and annually reimburse the department of public health and each site community for the costs thereof until the facility license is transferred to the board pursuant to section forty-six. A copy of all environmental monitoring records and analyses shall be kept at the board field office in the site community for public review.

(c) The department of public health shall annually issue a report describing and evaluating the findings of the monitoring program. Within sixty days of issuance of such report, said department shall hold a public meeting in each site community and, upon request by the chief executive officer of such community, in each affected and neighboring community for public review and comment upon the findings contained therein. Said department shall consider and evaluate all comments made at such public meetings or submitted in writing within sixty days of the issuance of the report.

Added by St.1987, c. 549, § 5. Amended by St.1990, c. 177, § 215.

Historical and Statutory Notes

1990 Legislation

St.1990, c. 177, § 215, an emergency act, approved Aug. 7, 1990, in par. (a), in the first sentence, substituted "protection" for "quality engineering"..

§ 37. Commencement of facility construction

Upon the determination of the department of public health that the environmental monitoring program or detailed site characterization of the superior site has yielded representative baseline data, the operator may commence construction of the facility. The operator shall construct, install and, from time to time, in accordance with the regulations adopted under section sixteen and the conditions of its facility license, make additions or improvements to such structures and equipment as are necessary to operate the facility. Said department shall, in cooperation with officials of each site community and according to the regulations adopted pursuant to said section sixteen, periodically inspect such construction to ensure that such regulations and the conditions of the license are satisfied. The board shall appoint a resident engineer having the experience and expertise specified in section forty-two J of chapter seven, who shall represent the board daily at the superior site during the construction of the facility and who shall, in cooperation with officials of each site community, check, inspect and report to the board as to events at the construction site, in order to ensure that the terms of the comprehensive operating contract are satisfied. The deputy commissioner of the division of capital planning and operations shall assist said department and the board in fulfilling their obligations under this section, and shall advise them on the adequacy of construction activities.

Added by St.1987, c. 549, § 5.

§ 38. Payment by operator equal to expected annual operating budget; proposed fees and waste acceptance criteria schedule

(a) Upon the issuance of a facility license pursuant to section thirty-one, and annually thereafter, until the facility license is transferred to the board pursuant to section forty-six, the department of public health shall establish a payment to be made by the operator equal to said departments expected annual operating budget for the next fiscal year for its activities with respect to the facility other than those for which reimbursement has been made pursuant to section thirty-six; provided, however, that such payment shall be adjusted by the amount of any operating deficit or surplus, previously incurred by said department with respect to such activities, in accordance with procedures established by regulation of said department. The operator shall make such payment to the commonwealth prior to the commencement of the fiscal year.

(b) The operator shall annually submit to the board a proposed schedule of fees and criteria for acceptance of low-level radioactive waste. Such schedule shall be based on the classification system contained in the management plan adopted pursuant to section twelve, shall be designed so as to promote source minimization, volume minimization and storage for decay by generators, shall establish service charges for waste shipments found not to be in compliance with applicable regulations and conditions of the facility license, and shall establish fees which are adequate to reimburse the operator for all reasonable expenses of facility development and operation; all reasonable community compensation guaranteed to site, neighboring and affected communities in the comprehensive operating contract executed pursuant to section thirty-three; the department of public health's required annual payment established pursuant to this section; and a reasonable profit from the operation of the facility; and shall establish waste acceptance criteria, consistent with the management plan and adequate to assure proper and efficient operation of the facility; source minimization, volume minimization and storage for decay in compliance with the regulations adopted by said department pursuant to section thirteen; and conservation of facility resources. Such waste acceptance criteria shall specify that no low-level radioactive waste shall be accepted from an electric-power-generating facility if such waste requires management more stringent than the most

stringent management required for any low-level radioactive waste which may be accepted at the facility from another generator. The operator's proposed schedule shall be accompanied by a certified audit of gross operating receipts from fees and surcharges imposed for acceptance of low-level radioactive waste at the facility during the current and prior fiscal years and a verification under oath that all compensation required to be paid by the operator to each site, neighboring and affected community by the comprehensive operating contract has been paid, and that all surcharges collected for the Low-Level Radioactive Waste Trust Fund have been remitted to the state treasurer in accordance with the requirements of the comprehensive operating contract executed pursuant to section thirty-three. All books and records of the operator shall be subject to audit pursuant to section twelve of chapter eleven.

(c) The board, after notice and opportunity for hearing, shall approve, modify or reject the schedule of fees and waste acceptance criteria submitted by the operator and establish annually a schedule of surcharges for the Low-Level Radioactive Waste Trust Fund established in section forty-one. Such fees, criteria and surcharges shall be imposed as conditions of acceptance of all low-level radioactive waste at the facility until a new or revised schedule is approved by the board.

Added by St.1987, c. 549, § 5. Amended by St.1988, c. 199, § 25.

Historical and Statutory Notes

1988 Legislation

St.1988, c. 199, § 25, an emergency act, approved July 26, 1988, in the third sentence of par. (b), substituted "more stringent than" for "more stringent that".

§ 39. Determination of operator's compliance with comprehensive operating contract; notice to generators

(a) Upon written notification by the operator that the facility is ready to accept low-level radioactive waste, and upon written notification by the department of public health that the facility is in compliance with all regulations and conditions of the facility license, the board shall determine whether the operator is in compliance with the comprehensive operating contract. If it is so determined, then the facility shall commence operation.

(b) Within seven days of the board's determination, the operator shall notify all generators of the date on which the operator will accept low-level radioactive waste from such generators. Included in such notice shall be a statement of the terms, conditions and criteria for low-level radioactive waste acceptance at the facility.

Added by St.1987, c. 549, § 5.

§ 40. Operation of facility; temporary or permanent closure; inspection report

(a) The facility shall be operated in accordance with this section and with regulations adopted under section sixteen. All shipments of low-level radioactive waste shall, upon arrival at the facility, enter the facility, but shall not proceed into the waste management area for unloading until inspected by the department of public health and found to be in compliance with applicable regulations and conditions of the facility license. Shipments found not to be in compliance shall proceed to a controlled area within the facility to await action to remedy the situation, and the board of health of each site community shall be so notified by the operator. Shipments found to be in compliance shall proceed into the waste management area for unloading. After a transport vehicle is unloaded and leaves the waste management area, it shall not leave the facility until it is again inspected by the department of public health and decontaminated, if necessary.

(b) The department of public health, in consultation with the board, may issue an order temporarily or permanently closing a facility prior to its scheduled closing date if it finds that there is a potential hazard to public health, safety or the environment which justifies such temporary or permanent closure. A facility that is temporarily closed shall remain closed as long as necessary for remedial action and, in any event, throughout any period

of facility clean-up and stabilization. Prior to authorizing the reopening of a temporarily closed facility, said department shall conduct at least one public meeting on the reopening in each site community and other public meetings in neighboring communities upon request by the chief executive officer of such community, and shall issue a summary response to all comments made at such public meetings or made in writing during the time the facility is temporarily closed and an explanation of the reasons for authorizing the reopening.

(c) The department of public health shall annually prepare a report summarizing its inspection and enforcement activities with respect to the facility and shall transmit a copy of such report to the board and the board of health of each site community.

Added by St.1987, c. 549, § 5. Amended by St.1988, c. 199, §§ 26, 27.

Historical and Statutory Notes

1988 Legislation

St.1988, c. 199, § 26, an emergency act, approved July 26, 1988, in the first sentence of par. (b), substituted "The" for "the".

Section 27 of St.1988, c. 199, in par. (c), substituted "The" for "the".

§ 41. Contingent liability account; institutional control account

(a) There is hereby established within the Low-Level Radioactive Waste Trust Fund, a contingent liability account and the institutional control account. The board shall determine annually the amount of revenues, raised from the surcharges imposed pursuant to section thirty-eight, that shall be deposited within each account; provided, however, that after such deposits, no amounts so deposited may be transferred between such accounts.

(b) The contingent liability account shall be used to pay compensation for injuries to persons, land or property resulting from the management of low-level radioactive waste pursuant to section nine.

(c) The institutional control account shall be used to pay institutional control costs pursuant to sections nine and forty-seven. The account shall be used by the board to purchase insurance coverage or otherwise to ensure the availability of funds to meet liability claims during the institutional control period; provided, however, that no portion of the monies held in the institutional control account may be used to satisfy judgments or settlements pursuant to section nine or for any other purpose other than institutional control of a facility.

Added by St.1987, c. 549, § 5.

§ 42. Administration of the Low-Level Radioactive Waste Trust Fund

The Low-Level Radioactive Waste Trust Fund, established by section thirty-five H of chapter ten, shall be administered by the board, without liability on the part of the commonwealth beyond the amounts credited to and earned by the fund.

The treasurer shall make payments from accounts of said fund upon receipt of a warrant listing all payments to be made and the accounts to be debited, which has been approved in writing by the board.

The state treasurer shall on or before July first of each year, submit to the board, the governor, the clerk of the senate and the clerk of the house of representatives, an annual report for the previous fiscal year. Said report shall include a statement of the revenues and disbursements of said Fund for the fiscal year, the balance at the beginning and the end of the fiscal year for each account within the trust fund, and any other information the treasurer deems appropriate.

Added by St.1987, c. 549, § 5.

§ 43. Facility closure plan

(a) At least one year prior to the date scheduled for facility closure in the facility closure plan required to be prepared and maintained by regulations issued pursuant to

section sixteen, the operator shall submit such plan to the department of public health and the management board. Said department shall conduct a public meeting on the plan at times to be determined after consultation with the board in each site community and other public meetings in neighboring communities upon request by the chief executive officer of such community. The board shall participate in each such public meeting. Said department shall accept written comments on the plan submitted by any interested person within forty-five days of the public notice of the availability of the plan. Prior to its acceptance of the plan said departments shall consider and evaluate all comments made at a public meeting or submitted in writing.

(b) Upon acceptance of such plan by said department and the board, the operator shall implement such plan according to the closure schedule contained therein. Said department shall, in cooperation with appropriate officials of each site community and according to regulations adopted pursuant to section sixteen, periodically inspect the operator's implementation of the facility closure plan to ensure that such regulations and the conditions of the facility license are satisfied. The board shall, in cooperation with appropriate officials of each site community, periodically, inspect the operator's implementation of the facility closure plan to ensure that the terms of the comprehensive operating contract are satisfied and that steps necessary to allow the board to accept transfer of the facility license pursuant to section forty-six are taken.

Added by St.1987, c. 549, § 5.

§ 44. Active observation and maintenance of facility

Upon completion of site closure activities, the operator shall, for no less than five years thereafter, engage in active observation and maintenance of the facility in accordance with regulations adopted pursuant to section sixteen and the conditions of the facility license. By the end of such time, the operator shall transfer all records of its development, operation, closure and post-closure observation and maintenance of the facility to the board.

Added by St.1987, c. 549, § 5.

§ 45. Phase VI of the Low-Level Radioactive Waste Management Act; institutional control of facility

Institutional control of a facility shall be conducted, subject to appropriation, in accordance with sections forty-six and forty-seven, which shall be known and may be cited as "Phase VI of the Low-Level Radioactive Waste Management Act", and in accordance with the regulations adopted pursuant to section sixteen. The provisions of these sections and regulations shall be implemented so as to provide for the safe and orderly institutional control of a facility following transfer of the facility license from the operator to the board.

Added by St.1987, c. 549, § 5.

§ 46. Transfer of facility license from operator

(a) No sooner than five years after the implementation of the site closure plan pursuant to section forty-four, the board shall accept transfer of the facility license from the operator, if it determines that the operator has fulfilled all of its obligations under the comprehensive operating contract executed pursuant to section thirty-three. No fewer than ninety days prior to such vote, the board shall issue a draft plan for institutional control of the facility in accordance with the regulations adopted under section sixteen for public review and comment. The board shall conduct a public meeting on the plan of each site community and other public meetings in neighboring communities upon request by the chief executive officer of such community. The board shall accept written comments on the plan submitted by any interested person within forty-five days of the public notice of the availability of the plan. Prior to its vote to accept transfer of the license and adopt the plan, the board shall consider and evaluate all comments made at a public meeting or submitted in writing.

(b) Upon the board's decision to accept transfer of the facility license the department of public health shall, after notice and opportunity for hearing, determine whether to allow such transfer. The decision of said department to approve facility license transfer shall be based on a determination that the operator's obligations under section forty-four have been fulfilled and that the board's program for institutional control of the facility is adequate to protect the public health, safety and the environment. Such decision shall specify, based on the characterization of the facility and of the low-level radioactive waste present at the site, a period of time during which institutional control shall continue, or a procedure for approving termination by the board of institutional control following a specified period of time. The institutional control period shall not be less than the minimum time required for any low-level radioactive waste present at the site to decay to the maximum concentrations above natural background levels permitted to be released into air or water in unrestricted areas under federal and state law.

(c) The operator shall not be required to submit a report to the state ethics commission and the inspector general, in accordance with section twenty-two, for any year after the year during which the facility license is transferred pursuant to this section.

Added by St.1987, c. 549, § 5.

§ 47. Institutional control of facility; annual report; public meetings

The board shall be responsible for institutional control of the facility in accordance with the program approved by the department of public health and regulations adopted pursuant to section sixteen. The board shall annually issue a report of its institutional control of the facility for public review and comment. Within sixty days of issuance of such report, the board shall hold a public meeting in each site community and other public meetings in neighboring communities upon request by the chief executive officer of such community. The board shall consider and evaluate all comments made at such public meetings or submitted in writing within sixty days of the issuance of the report. Said department shall issue an annual report of the supervision of such institutional control activities for public review and comment. Within sixty days of issuance of such report, said department shall hold a public meeting in each site community and other public meetings in neighboring communities, upon request by the chief executive officer of such community. Said department shall consider and evaluate all comments made at such public meetings or submitted in writing within sixty days of the issuance of the report.

Added by St.1987, c. 549, § 5.

§ 48. Statutes not applicable

The selection of an operator and the development of a facility pursuant to this chapter shall, for the purposes of section forty-two B of chapter seven, be construed as an alternative method of design and construction services approved by the legislature, and shall not be subject to sections thirty-eight A1/2 to thirty-eight N, inclusive, of said chapter seven or of sections forty-four A to forty-four J, inclusive, of chapter one hundred and forty-nine.

Added by St.1987, c. 549, § 5.

Appendix B: Chapter 549, Section 6, of the Acts of 1987

The low-level radioactive waste management board, established under the provisions of section two of chapter one hundred and eleven G[1] of the General Laws is hereby authorized and directed to represent the commonwealth in any and all negotiations with other states for the purpose of reaching an interstate compact agreement to provide for the establishment and operation of regional disposal facilities for low-level radioactive waste. In carrying out the duties established hereunder, said board may initiate negotiations with any state it deems appropriate to meet the needs of the commonwealth with respect to such facilities upon a majority vote of the board. The board shall include as part of its management plan adopted pursuant to section eleven of chapter one hundred and eleven H of the General Laws a detailed report which shall include a summary of all negotiations conducted prior to the establishment of the board, a study of the feasibility of the commonwealth entering into a regional compact which shall identify those states the board deems appropriate for the commonwealth to negotiate with. After the issuance of the detailed report the board shall report semiannually to the joint committee on natural resources on its progress in its negotiations for a regional compact which shall include any additional states which the board determined it is appropriate to negotiate with or any other developments which impact on the establishment of an interstate compact, including any cost to the commonwealth for the disposal of low-level radioactive waste or the volume of waste to be stored in the commonwealth arising from the regional compact negotiations.

[1] So in original; should read "chapter one hundred and eleven H."

Appendix C: Public Law 96-573. Low-Level Radioactive Waste Policy Act

AN ACT

To set forth a Federal policy for the disposal of low-level radioactive wastes, and for other purposes.

Dec. 22, 1980
[S. 2189]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Low-Level Radioactive Waste Policy Act.

SHORT TITLE

SECTION 1. This Act may be cited as the "Low-Level Radioactive Waste Policy Act". 42 USC 2021b note.

DEFINITIONS

SEC. 2. As used in this Act— 42 USC 2021b.

(1) The term "disposal" means the isolation of low-level radioactive waste pursuant to requirements established by the Nuclear Regulatory Commission under applicable laws.

(2) The term "low-level radioactive waste" means radioactive waste not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or byproduct material as defined in section 11 e. (2) of the Atomic Energy Act of 1954.

(3) The term "State" means any State of the United States, the District of Columbia, and, subject to the provisions of Public Law 96–205, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, the Northern Mariana Islands, the Trust Territory of the Pacific Islands, and any other territory or possession of the United States.

(4) For purposes of this Act the term "atomic energy defense activities of the Secretary" includes those activities and facilities of the Department of Energy carrying out the function of—

(i) Naval reactors development and propulsion,
(ii) weapons activities, verification and control technology,
(iii) defense materials production,
(iv) inertial confinement fusion,
(v) defense waste management, and
(vi) defense nuclear materials security and safeguards (all as included in the Department of Energy appropriations account in any fiscal year for atomic energy defense activities).

GENERAL PROVISIONS

SEC. 3. (a) Compacts established under this Act or actions taken under such compacts shall not be applicable to the transportation, management, or disposal of low-level radioactive waste from atomic energy defense activities of the Secretary or Federal research and development activities. 42 USC 2021c.

(b) Any facility established or operated exclusively for the disposal of low-level radioactive waste produced by atomic energy defense activities of the Secretary or Federal research and development

activities shall not be subject to compacts established under this Act or actions taken under such compacts.

LOW-LEVEL RADIOACTIVE WASTE DISPOSAL

State compacts regarding regional facilities.
42 USC 2021d.

SEC. 4. (a)(1) It is the policy of the Federal Government that—

(A) each State is responsible for providing for the availability of capacity either within or outside the State for the disposal of low-level radioactive waste generated within its borders except for waste generated as a result of defense activities of the Secretary or Federal research and development activities; and

(B) low-level radioactive waste can be most safely and efficiently managed on a regional basis.

(2)(A) To carry out the policy set forth in paragraph (1), the States may enter into such compacts as may be necessary to provide for the establishment and operation of regional disposal facilities for low-level radioactive waste.

Congressional consent.

(B) A compact entered into under subparagraph (A) shall not take effect until the Congress has by law consented to the compact. Each such compact shall provide that every 5 years after the compact has taken effect the Congress may by law withdraw its consent. After January 1, 1986, any such compact may restrict the use of the regional disposal facilities under the compact to the disposal of low-level radioactive waste generated within the region.

Report to Congress and States.

(b)(1) In order to assist the States in carrying out the policy set forth in subsection (a)(1), the Secretary shall prepare and submit to Congress and to each of the States within 120 days after the date of the enactment of this Act a report which—

(A) defines the disposal capacity needed for present and future low-level radioactive waste on a regional basis;

(B) defines the status of all commercial low-level radioactive waste disposal sites and includes an evaluation of the license status of each such site, the state of operation of each site, including operating history, an analysis of the adequacy of disposal technology employed at each site to contain low-level radioactive wastes for their hazardous lifetimes, and such recommendations as the Secretary considers appropriate to assure protection of the public health and safety from wastes transported to such sites;

(C) evaluates the transportation requirements on a regional basis and in comparison with performance of present transportation practices for the shipment of low-level radioactive wastes, including an inventory of types and quantities of low-level wastes, and evaluation of shipment requirements for each type of waste and an evaluation of the ability of generators, shippers, and carriers to meet such requirements; and

(D) evaluates the capability of the low-level radioactive waste disposal facilities owned and operated by the Department of Energy to provide interim storage for commercially generated low-level waste and estimates the costs associated with such interim storage.

(2) In carrying out this subsection, the Secretary shall consult with the Governors of the States, the Nuclear Regulatory Commission, the Environmental Protection Agency, the United States Geological Survey, and the Secretary of Transportation, and such other agencies and departments as he finds appropriate.

Approved December 22, 1980.

LEGISLATIVE HISTORY:

SENATE REPORT No. 96-548 (Comm. on Energy and Natural Resources).
CONGRESSIONAL RECORD, Vol. 126 (1980):
- July 28-30, considered and passed Senate.
- Dec. 3, H.R. 8378 considered and passed House; passage vacated and S. 2189, amended, passed in lieu.
- Dec. 13, Senate agreed to the House amendment with amendments; House agreed to Senate amendments.

Appendix D: Public Law 99-240. Low-Level Radioactive Waste Policy Amendments Act

An Act

Jan. 15, 1986
[H.R. 1083]

To amend the Low-Level Radioactive Waste Policy Act to improve procedures for the implementation of compacts providing for the establishment and operation of regional disposal facilities for low-level radioactive waste; to grant the consent of the Congress to certain interstate compacts on low-level radioactive waste; and for other purposes.

State and local governments.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Low-Level Radioactive Waste Policy Amendments Act of 1985. 42 USC 2021b note.

TITLE I—LOW-LEVEL RADIOACTIVE WASTE POLICY AMENDMENTS ACT OF 1985

SEC. 101. SHORT TITLE.

This Title may be cited as the "Low-Level Radioactive Waste Policy Amendments Act of 1985".

SEC. 102. AMENDMENT TO THE LOW-LEVEL RADIOACTIVE WASTE POLICY ACT.

42 USC 2021b–2021d, 2021b note.

The Low-Level Radioactive Waste Policy Act (42 U.S.C. 2021b et seq.) is amended by striking out sections 1, 2, 3, and 4 and inserting in lieu thereof the following:

42 USC 2021b note.

"SECTION 1. SHORT TITLE.

"This Act may be cited as the 'Low-Level Radioactive Waste Policy Act'.

42 USC 2021b.

"SEC. 2. DEFINITIONS.

"For purposes of this Act:

"(1) Agreement State.—The term 'agreement State' means a State that—

"(A) has entered into an agreement with the Nuclear Regulatory Commission under section 274 of the Atomic Energy Act of 1954 (42 U.S.C. 2021); and

"(B) has authority to regulate the disposal of low-level radioactive waste under such agreement.

"(2) Allocation.—The term 'allocation' means the assignment of a specific amount of low-level radioactive waste disposal capacity to a commercial nuclear power reactor for which access is required to be provided by sited States subject to the conditions specified under this Act.

"(3) Commercial nuclear power reactor.—The term 'commercial nuclear power reactor' means any unit of a civilian light-water moderated utilization facility required to be licensed under section 103 or 104b. of the Atomic Energy Act of 1954 (42 U.S.C. 2133 or 2134(b)).

"(4) Compact.—The term 'compact' means a compact entered into by two or more States pursuant to this Act.

"(5) COMPACT COMMISSION.—The term 'compact commission' means the regional commission, committee, or board established in a compact to administer such compact.

"(6) COMPACT REGION.—The term 'compact region' means the area consisting of all States that are members of a compact.

"(7) DISPOSAL.—The term 'disposal' means the permanent isolation of low-level radioactive waste pursuant to the requirements established by the Nuclear Regulatory Commission under applicable laws, or by an agreement State if such isolation occurs in such agreement State.

"(8) GENERATE.—The term 'generate', when used in relation to low-level radioactive waste, means to produce low-level radioactive waste.

"(9) LOW-LEVEL RADIOACTIVE WASTE.—The term 'low-level radioactive waste' means radioactive material that—

"(A) is not high-level radioactive waste, spent nuclear fuel, or byproduct material (as defined in section 11e.(2) of the Atomic Energy Act of 1954 (42 U.S.C. 2014(e)(2))); and

"(B) the Nuclear Regulatory Commission, consistent with existing law and in accordance with paragraph (A), classifies as low-level radioactive waste.

"(10) NON-SITED COMPACT REGION.—The term 'non-sited compact region' means any compact region that is not a sited compact region.

"(11) REGIONAL DISPOSAL FACILITY.—The term 'regional disposal facility' means a non-Federal low-level radioactive waste disposal facility in operation on January 1, 1985, or subsequently established and operated under a compact.

"(12) SECRETARY.—The term 'Secretary' means the Secretary of Energy.

"(13) SITED COMPACT REGION.—The term 'sited compact region' means a compact region in which there is located one of the regional disposal facilities at Barnwell, in the State of South Carolina; Richland, in the State of Washington; or Beatty, in the State of Nevada.

South Carolina.
Washington.
Nevada.

"(14) STATE.—The term 'State' means any State of the United States, the District of Columbia, and the Commonwealth of Puerto Rico.

"SEC. 3. RESPONSIBILITIES FOR DISPOSAL OF LOW-LEVEL RADIOACTIVE WASTE.

42 USC 2021c.

"SECTION 3(a)(1) STATE RESPONSIBILITIES.—Each State shall be responsible for providing, either by itself or in cooperation with other States, for the disposal of—

"(A) low-level radioactive waste generated within the State (other than by the Federal Government) that consists of or contains class A, B, or C radioactive waste as defined by section 61.55 of title 10, Code of Federal Regulations, as in effect on January 26, 1983;

"(B) low-level radioactive waste described in subparagraph (A) that is generated by the Federal Government except such waste that is—

Vessels.

"(i) owned or generated by the Department of Energy;
"(ii) owned or generated by the United States Navy as a result of the decommissioning of vessels of the United States Navy; or

Research and development.

"(iii) owned or generated as a result of any research, development, testing, or production of any atomic weapon; and

"(C) low-level radioactive waste described in subparagraphs (A) and (B) that is generated outside of the State and accepted for disposal in accordance with sections 5 or 6.

Post, pp. 1846, 1855.

"(2) No regional disposal facility may be required to accept for disposal any material—

"(A) that is not low-level radioactive waste as defined by section 61.55 of title 10, Code of Federal Regulations, as in effect on January 26, 1983, or

"(B) identified under the Formerly Utilized Sites Remedial Action Program.

Nothing in this paragraph shall be deemed to prohibit a State, subject to the provisions of its compact, or a compact region from accepting for disposal any material identified in subparagraph (A) or (B).

"(b)(1) The Federal Government shall be responsible for the disposal of—

"(A) low-level radioactive waste owned or generated by the Department of Energy;

Vessels.

"(B) low-level radioactive waste owned or generated by the United States Navy as a result of the decommissioning of vessels of the United States Navy;

Research and development.

"(C) low-level radioactive waste owned or generated by the Federal Government as a result of any research, development, testing, or production of any atomic weapon; and

"(D) any other low-level radioactive waste with concentrations of radionuclides that exceed the limits established by the Commission for class C radioactive waste, as defined by section 61.55 of title 10, Code of Federal Regulations, as in effect on January 26, 1983.

Health. Safety.

42 USC 2011 note.

"(2) All radioactive waste designated a Federal responsibility pursuant to subparagraph (b)(1)(D) that results from activities licensed by the Nuclear Regulatory Commission under the Atomic Energy Act of 1954, as amended, shall be disposed of in a facility licensed by the Nuclear Regulatory Commission that the Commission determines is adequate to protect the public health and safety.

Report.

"(3) Not later than 12 months after the date of enactment of this Act, the Secretary shall submit to the Congress a comprehensive report setting forth the recommendations of the Secretary for ensuring the safe disposal of all radioactive waste designated a Federal responsibility pursuant to subparagraph (b)(1)(D). Such report shall include—

"(A) an identification of the radioactive waste involved, including the source of such waste, and the volume, concentration, and other relevant characteristics of such waste;

"(B) an identification of the Federal and non-Federal options for disposal of such radioactive waste;

"(C) a description of the actions proposed to ensure the safe disposal of such radioactive waste;

"(D) a description of the projected costs of undertaking such actions;

"(E) an identification of the options for ensuring that the beneficiaries of the activities resulting in the generation of such radioactive wastes bear all reasonable costs of disposing of such wastes; and

"(F) an identification of any statutory authority required for disposal of such waste.

"(4) The Secretary may not dispose of any radioactive waste designated a Federal responsibility pursuant to paragraph (b)(1)(D) that becomes a Federal responsibility for the first time pursuant to such paragraph until ninety days after the report prepared pursuant to paragraph (3) has been submitted to the Congress. Prohibition. Report.

"SEC. 4. REGIONAL COMPACTS FOR DISPOSAL OF LOW-LEVEL RADIOACTIVE WASTE. 42 USC 2021d.

"(a) IN GENERAL.—

"(1) FEDERAL POLICY.—It is the policy of the Federal Government that the responsibilities of the States under section 3 for the disposal of low-level radioactive waste can be most safely and effectively managed on a regional basis. *Ante*, p. 1843.

"(2) INTERSTATE COMPACTS.—To carry out the policy set forth in paragraph (1), the States may enter into such compacts as may be necessary to provide for the establishment and operation of regional disposal facilities for low-level radioactive waste.

"(b) APPLICABILITY TO FEDERAL ACTIVITIES.—

"(1) IN GENERAL.—

"(A) ACTIVITIES OF THE SECRETARY.—Except as provided in subparagraph (B), no compact or action taken under a compact shall be applicable to the transportation, management, or disposal of any low-level radioactive waste designated in section 3(a)(1)(B) (i)–(iii). Prohibition.

"(B) FEDERAL LOW-LEVEL RADIOACTIVE WASTE DISPOSED OF AT NON-FEDERAL FACILITIES.—Low-level radioactive waste owned or generated by the Federal Government that is disposed of at a regional disposal facility or non-Federal disposal facility within a State that is not a member of a compact shall be subject to the same conditions, regulations, requirements, fees, taxes, and surcharges imposed by the compact commission, and by the State in which such facility is located, in the same manner and to the same extent as any low-level radioactive waste not generated by the Federal Government.

"(2) FEDERAL LOW-LEVEL RADIOACTIVE WASTE DISPOSAL FACILITIES.—Any low-level radioactive waste disposal facility established or operated exclusively for the disposal of low-level radioactive waste owned or generated by the Federal Government shall not be subject to any compact or any action taken under a compact. Prohibition.

"(3) EFFECT OF COMPACTS ON FEDERAL LAW.—Nothing contained in this Act or any compact may be construed to confer Prohibition.

any new authority on any compact commission or State—

"(A) to regulate the packaging, generation, treatment, storage, disposal, or transportation of low-level radioactive waste in a manner incompatible with the regulations of the Nuclear Regulatory Commission or inconsistent with the regulations of the Department of Transportation;

Transportation. Regulations.

"(B) to regulate health, safety, or environmental hazards from source material, byproduct material, or special nuclear material;

Health. Safety. Pollution.

"(C) to inspect the facilities of licensees of the Nuclear Regulatory Commission;

Government organization and employees.

"(D) to inspect security areas or operations at the site of the generation of any low-level radioactive waste by the Federal Government, or to inspect classified information related to such areas or operations; or

"(E) to require indemnification pursuant to the provisions of chapter 171 of title 28, United States Code (commonly referred to as the Federal Tort Claims Act), or section 170 of the Atomic Energy Act of 1954 (42 U.S.C. 2210) (commonly referred to as the Price-Anderson Act), whichever is applicable.

28 USC 2671 *et seq.*

Prohibition.

"(4) Federal authority.—Except as expressly provided in this Act, nothing contained in this Act or any compact may be construed to limit the applicability of any Federal law or to diminish or otherwise impair the jurisdiction of any Federal agency, or to alter, amend, or otherwise affect any Federal law governing the judicial review of any action taken pursuant to any compact.

Prohibition.

"(5) State authority preserved.—Except as expressly provided in this Act, nothing contained in this Act expands, diminishes, or otherwise affects State law.

Prohibition.

"(c) Restricted Use of Regional Disposal Facilities.—Any authority in a compact to restrict the use of the regional disposal facilities under the compact to the disposal of low-level radioactive waste generated within the compact region shall not take effect before each of the following occurs:

"(1) January 1, 1986; and

"(2) the Congress by law consents to the compact.

"(d) Congressional Review.—Each compact shall provide that every 5 years after the compact has taken effect the Congress may by law withdraw its consent.

42 USC 2021e.

"SEC. 5. LIMITED AVAILABILITY OF CERTAIN REGIONAL DISPOSAL FACILITIES DURING TRANSITION AND LICENSING PERIODS.

"(a) Availability of Disposal Capacity.—

"(1) Pressurized-water and boiling water reactors.—During the seven-year period beginning January 1, 1986 and ending December 31, 1992, subject to the provisions of subsections (b) through (g), each State in which there is located a regional disposal facility referred to in paragraphs (1) through (3) of subsection (b) shall make disposal capacity available for low-level radioactive waste generated by pressurized water and boiling water commercial nuclear power reactors in accordance with the allocations established in subsection (c).

"(2) OTHER SOURCES OF LOW-LEVEL RADIOACTIVE WASTE.—During the seven-year period beginning January 1, 1986 and ending December 31, 1992, subject to the provisions of subsections (b) through (g), each State in which there is located a regional disposal facility referred to in paragraphs (1) through (3) of subsection (b) shall make disposal capacity available for low-level radioactive waste generated by any source not referred to in paragraph (1).

"(3) ALLOCATION OF DISPOSAL CAPACITY.—

"(A) During the seven-year period beginning January 1, 1986 and ending December 31, 1992, low-level radioactive waste generated within a sited compact region shall be accorded priority under this section in the allocation of available disposal capacity at a regional disposal facility referred to in paragraphs (1) through (3) of subsection (b) and located in the sited compact region in which such waste is generated.

"(B) Any State in which a regional disposal facility referred to in paragraphs (1) through (3) of subsection (b) is located may, subject to the provisions of its compact, prohibit the disposal at such facility of low-level radioactive waste generated outside of the compact region if the disposal of such waste in any given calendar year, together with all other low-level radioactive waste disposed of at such facility within that same calendar year, would result in that facility disposing of a total annual volume of low-level radioactive waste in excess of 100 per centum of the average annual volume for such facility designated in subsection (b): *Provided, however,* That in the event that all three States in which regional disposal facilities referred to in paragraphs (1) through (3) of subsection (b) act to prohibit the disposal of low-level radioactive waste pursuant to this subparagraph, each such State shall, in accordance with any applicable procedures of its compact, permit, as necessary, the disposal of additional quantities of such waste in increments of 10 per centum of the average annual volume for each such facility designated in subsection (b).

"(C) Nothing in this paragraph shall require any disposal facility or State referred to in paragraphs (1) through (3) of subsection (b) to accept for disposal low-level radioactive waste in excess of the total amounts designated in subsection (b). Prohibition.

"(4) CESSATION OF OPERATION OF LOW-LEVEL RADIOACTIVE WASTE DISPOSAL FACILITY.—No provision of this section shall be construed to obligate any State referred to in paragraphs (1) through (3) of subsection (b) to accept low-level radioactive waste from any source in the event that the regional disposal facility located in such State ceases operations. Prohibition.

"(b) LIMITATIONS.—The availability of disposal capacity for low-level radioactive waste from any source shall be subject to the following limitations:

"(1) BARNWELL, SOUTH CAROLINA.—The State of South Carolina, in accordance with the provisions of its compact, may limit

the volume of low-level radioactive waste accepted for disposal at the regional disposal facility located at Barnwell, South Carolina to a total of 8,400,000 cubic feet of low-level radioactive waste during the 7-year period beginning January 1, 1986, and ending December 31, 1992 (as based on an average annual volume of 1,200,000 cubic feet of low-level radioactive waste).

"(2) RICHLAND, WASHINGTON.—The State of Washington, in accordance with the provisions of its compact, may limit the volume of low-level radioactive waste accepted for disposal at the regional disposal facility located at Richland, Washington to a total of 9,800,000 cubic feet of low-level radioactive waste during the 7-year period beginning January 1, 1986, and ending December 31, 1992 (as based on an average annual volume of 1,400,000 cubic feet of low-level radioactive waste).

"(3) BEATTY, NEVADA.—The State of Nevada, in accordance with the provisions of its compact, may limit the volume of low-level radioactive waste accepted for disposal at the regional disposal facility located at Beatty, Nevada to a total of 1,400,000 cubic feet of low-level radioactive waste during the 7-year period beginning January 1, 1986, and ending December 31, 1992 (as based on an average annual volume of 200,000 cubic feet of low-level radioactive waste).

"(c) COMMERCIAL NUCLEAR POWER REACTOR ALLOCATIONS.—

"(1) AMOUNT.—Subject to the provisions of subsections (a) through (g) each commercial nuclear power reactor shall upon request receive an allocation of low-level radioactive waste disposal capacity (in cubic feet) at the facilities referred to in subsection (b) during the 4-year transition period beginning January 1, 1986, and ending December 31, 1989, and during the 3-year licensing period beginning January 1, 1990, and ending December 31, 1992, in an amount calculated by multiplying the appropriate number from the following table by the number of months remaining in the applicable period as determined under paragraph (2).

"Reactor Type	4-year Transition Period		3-year Licensing Period	
	In Sited Region	All Other Locations	In Sited Region	All Other Locations
PWR	1027	871	934	685
BWR	2300	1951	2091	1533

"(2) METHOD OF CALCULATION.—For purposes of calculating the aggregate amount of disposal capacity available to a commercial nuclear power reactor under this subsection, the number of months shall be computed beginning with the first month of the applicable period, or the sixteenth month after receipt of a full power operating license, whichever occurs later.

"(3) UNUSED ALLOCATIONS.—Any unused allocation under paragraph (1) received by a reactor during the transition period or the licensing period may be used at any time after such

reactor receives its full power license or after the beginning of the pertinent period, whichever is later, but not in any event after December 31, 1992, or after commencement of operation of a regional disposal facility in the compact region or State in which such reactor is located, whichever occurs first.

"(4) TRANSFERABILITY.—Any commercial nuclear power reactor in a State or compact region that is in compliance with the requirements of subsection (e) may assign any disposal capacity allocated to it under this subsection to any other person in each State or compact region. Such assignment may be for valuable consideration and shall be in writing, copies of which shall be filed at the affected compact commissions and States, along with the assignor's unconditional written waiver of the disposal capacity being assigned.

"(5) UNUSUAL VOLUMES.—

"(A) The Secretary may, upon petition by the owner or operator of any commercial nuclear power reactor, allocate to such reactor disposal capacity in excess of the amount calculated under paragraph (1) if the Secretary finds and states in writing his reasons for so finding that making additional capacity available for such reactor through this paragraph is required to permit unusual or unexpected operating, maintenance, repair or safety activities.

"(B) The Secretary may not make allocations pursuant to subparagraph (A) that would result in the acceptance for disposal of more than 800,000 cubic feet of low-level radioactive waste or would result in the total of the allocations made pursuant to this subsection exceeding 11,900,000 cubic feet over the entire seven-year interim access period. Prohibition.

"(6) LIMITATION.—During the seven-year interim access period referred to in subsection (a), the disposal facilities referred to in subsection (b) shall not be required to accept more than 11,900,000 cubic feet of low-level radioactive waste generated by commercial nuclear power reactors. Prohibition.

"(d)(1) SURCHARGES.—The disposal of any low-level radioactive waste under this section (other than low-level radioactive waste generated in a sited compact region) may be charged a surcharge by the State in which the applicable regional disposal facility is located, in addition to the fees and surcharges generally applicable for disposal of low-level radioactive waste in the regional disposal facility involved. Except as provided in subsection (e)(2), such surcharges shall not exceed— Prohibition.

"(A) in 1986 and 1987, $10 per cubic foot of low-level radioactive waste;

"(B) in 1988 and 1989, $20 per cubic foot of low-level radioactive waste; and

"(C) in 1990, 1991, and 1992, $40 per cubic foot of low-level radioactive waste.

"(2) MILESTONE INCENTIVES.—

"(A) ESCROW ACCOUNT.—Twenty-five per centum of all surcharge fees received by a State pursuant to paragraph (1) during the seven-year period referred to in subsection (a) shall be transferred on a monthly basis to an escrow account held by the Secretary. The Secretary shall deposit all funds received in a

special escrow account. The funds so deposited shall not be the property of the United States. The Secretary shall act as trustee for such funds and shall invest them in interest-bearing United States Government Securities with the highest available yield. Such funds shall be held by the Secretary until—

"(i) paid or repaid in accordance with subparagraph (B) or (C); or

"(ii) paid to the State collecting such fees in accordance with subparagraph (F).

"(B) PAYMENTS.—

"(i) JULY 1, 1986.—The twenty-five per centum of any amount collected by a State under paragraph (1) for low-level radioactive waste disposed of under this section during the period beginning on the date of enactment of the Low-Level Radioactive Waste Policy Amendments Act of 1985 and ending June 30, 1986, and transferred to the Secretary under subparagraph (A), shall be paid by the Secretary in accordance with subparagraph (D) if the milestone described in subsection (e)(1)(A) is met by the State in which such waste originated.

"(ii) JANUARY 1, 1988.—The twenty-five per centum of any amount collected by a State under paragraph (1) for low-level radioactive waste disposed of under this section during the period beginning July 1, 1986 and ending December 31, 1987, and transferred to the Secretary under subparagraph (A), shall be paid by the Secretary in accordance with subparagraph (D) if the milestone described in subsection (e)(1)(B) is met by the State in which such waste originated (or its compact region, where applicable).

"(iii) JANUARY 1, 1990.—The twenty-five per centum of any amount collected by a State under paragraph (1) for low-level radioactive waste disposed of under this section during the period beginning January 1, 1988 and ending December 31, 1989, and transferred to the Secretary under subparagraph (A), shall be paid by the Secretary in accordance with subparagraph (D) if the milestone described in subsection (e)(1)(C) is met by the State in which such waste originated (or its compact region, where applicable).

"(iv) The twenty-five per centum of any amount collected by a State under paragraph (1) for low-level radioactive waste disposed of under this section during the period beginning January 1, 1990 and ending December 31, 1992, and transferred to the Secretary under subparagrah (A), shall be paid by the Secretary in accordance with subparagraph (D) if, by January 1, 1993, the State in which such waste originated (or its compact region, where applicable) is able to provide for the disposal of all low-level radioactive waste generated within such State or compact region.

"(C) FAILURE TO MEET JANUARY 1, 1993 DEADLINE.—If, by January 1, 1993, a State (or, where applicable, a compact region) in which low-level radioactive waste is generated is unable to provide for the disposal of all such waste generated within such State or compact region—

"(i) each State in which such waste is generated, upon the request of the generator or owner of the waste, shall take title to the waste, shall be obligated to take possession of the waste, and shall be liable for all damages directly or indirectly incurred by such generator or owner as a consequence of the failure of the State to take possession of the waste as soon after January 1, 1993 as the generator or owner notifies the State that the waste is available for shipment; or

"(ii) if such State elects not to take title to, take possession of, and assume liability for such waste, pursuant to clause (i), twenty-five per centum of any amount collected by a State under paragraph (1) for low-level radioactive waste disposed of under this section during the period beginning January 1, 1990 and ending December 31, 1992 shall be repaid, with interest, to each generator from whom such surcharge was collected. Repayments made pursuant to this clause shall be made on a monthly basis, with the first such repayment beginning on February 1, 1993, in an amount equal to one thirty-sixth of the total amount required to be repaid pursuant to this clause, and shall continue until the State (or, where applicable, compact region) in which such low-level radioactive waste is generated is able to provide for the disposal of all such waste generated within such State or compact region or until January 1, 1996, whichever is earlier.

If a State in which low-level radioactive waste is generated elects to take title to, take possession of, and assume liability for such waste pursuant to clause (i), such State shall be paid such amounts as are designated in subparagraph (B)(iv). If a State (or, where applicable, a compact region) in which low-level radioactive waste is generated provides for the disposal of such waste at any time after January 1, 1993 and prior to January 1, 1996, such State (or, where applicable, compact region) shall be paid in accordance with subparagraph (D) a lump sum amount equal to twenty-five per centum of any amount collected by a State under paragraph (1): *Provided, however,* That such payment shall be adjusted to reflect the remaining number of months between January 1, 1993 and January 1, 1996 for which such State (or, where applicable, compact region) provides for the disposal of such waste. If a State (or, where applicable, a compact region) in which low-level radioactive waste is generated is unable to provide for the disposal of all such waste generated within such State or compact region by January 1, 1996, each State in which such waste is generated, upon the request of the generator or owner of the waste, shall take title to the waste, be obligated to take possession of the waste, and shall be liable for all damages directly or indirectly incurred by such generator or owner as a consequence of the failure of the State to take possession of the waste as soon after January 1, 1996, as the generator or owner notifies the State that the waste is available for shipment.

"(D) Recipients of payments.—The payments described in subparagraphs (B) and (C) shall be paid within thirty days after

the applicable date—

"(i) if the State in which such waste originated is not a member of a compact region, to such State;

"(ii) if the State in which such waste originated is a member of the compact region, to the compact commission serving such State.

"(E) USES OF PAYMENTS.—

"(i) LIMITATIONS.—Any amount paid under subparagraphs (B) or (C) may only be used to—

"(I) establish low-level radioactive waste disposal facilities;

"(II) mitigate the impact of low-level radioactive waste disposal facilities on the host State;

"(III) regulate low-level radioactive waste disposal facilities; or

"(IV) ensure the decommissioning, closure, and care during the period of institutional control of low-level radioactive waste disposal facilities.

"(ii) REPORTS.—

"(I) RECIPIENT.—Any State or compact commission receiving a payment under subparagraphs (B) or (C) shall, on December 31 of each year in which any such funds are expended, submit a report to the Department of Energy itemizing any such expenditures.

"(II) DEPARTMENT OF ENERGY.—Not later than six months after receiving the reports under subclause (I), the Secretary shall submit to the Congress a summary of all such reports that shall include an assessment of the compliance of each such State or compact commission with the requirements of clause (i).

"(F) PAYMENT TO STATES.—Any amount collected by a State under paragraph (1) that is placed in escrow under subparagraph (A) and not paid to a State or compact commission under subparagraphs (B) and (C) or not repaid to a generator under subparagraph (C) shall be paid from such escrow account to such State collecting such payment under paragraph (1). Such payment shall be made not later than 30 days after a determination of ineligibility for a refund is made.

Prohibition.

"(G) PENALTY SURCHARGES.—No rebate shall be made under this subsection of any surcharge or penalty surcharge paid during a period of noncompliance with subsection (e)(1).

"(e) REQUIREMENTS FOR ACCESS TO REGIONAL DISPOSAL FACILITIES.—

"(1) REQUIREMENTS FOR NON-SITED COMPACT REGIONS AND NON-MEMBER STATES.—Each non-sited compact region, or State that is not a member of a compact region that does not have an operating disposal facility, shall comply with the following requirements:

"(A) By July 1, 1986, each such non-member State shall ratify compact legislation or, by the enactment of legislation or the certification of the Governor, indicate its intent to develop a site for the location of a low-level radioactive waste disposal facility within such State.

"(B) BY JANUARY 1, 1988.—

"(i) each non-sited compact region shall identify the State in which its low-level radioactive waste disposal facility is to be located, or shall have selected the developer for such facility and the site to be developed, and each compact region or the State in which its low-level radioactive waste disposal facility is to be located shall develop a siting plan for such facility providing detailed procedures and a schedule for establishing a facility location and preparing a facility license application and shall delegate authority to implement such plan;

"(ii) each non-member State shall develop a siting plan providing detailed procedures and a schedule for establishing a facility location and preparing a facility license application for a low-level radioactive waste disposal facility and shall delegate authority to implement such plan; and

"(iii) The siting plan required pursuant to this paragraph shall include a description of the optimum way to attain operation of the low-level radioactive waste disposal facility involved, within the time period specified in this Act. Such plan shall include a description of the objectives and a sequence of deadlines for all entities required to take action to implement such plan, including, to the extent practicable, an identification of the activities in which a delay in the start, or completion, of such activities will cause a delay in beginning facility operation. Such plan shall also identify, to the extent practicable, the process for (1) screening for broad siting areas; (2) identifying and evaluating specific candidate sites; and (3) characterizing the preferred site(s), completing all necessary environmental assessments, and preparing a license application for submission to the Nuclear Regulatory Commission or an Agreement State.

"(C) BY JANUARY 1, 1990.—

"(i) a complete application (as determined by the Nuclear Regulatory Commission or the appropriate agency of an agreement State) shall be filed for a license to operate a low-level radioactive waste disposal facility within each non-sited compact region or within each non-member State; or

"(ii) the Governor (or, for any State without a Governor, the chief executive officer) of any State that is not a member of a compact region in compliance with clause (i), or has not complied with such clause by its own actions, shall provide a written certification to the Nuclear Regulatory Commission, that such State will be capable of providing for, and will provide for, the storage, disposal, or management of any low-level radioactive waste generated within such State and requiring disposal after December 31, 1992, and include

a description of the actions that will be taken to ensure that such capacity exists.

"(D) By January 1, 1992, a complete application (as determined by the Nuclear Regulatory Commission or the appropriate agency of an agreement State) shall be filed for a license to operate a low-level radioactive waste disposal facility within each non-sited compact region or within each non-member State.

Federal Register, publication.

"(E) The Nuclear Regulatory Commission shall transmit any certification received under subparagraph (C) to the Congress and publish any such certification in the Federal Register.

Contracts.

"(F) Any State may, subject to all applicable provisions, if any, of any applicable compact, enter into an agreement with the compact commission of a region in which a regional disposal facility is located to provide for the disposal of all low-level radioactive waste generated within such State, and, by virtue of such agreement, may, with the approval of the State in which the regional disposal facility is located, be deemed to be in compliance with subparagraphs (A), (B), (C), and (D).

"(2) PENALTIES FOR FAILURE TO COMPLY.—

"(A) BY JULY 1, 1986.—If any State fails to comply with subparagraph (1)(A)—

"(i) any generator of low-level radioactive waste within such region or non-member State shall, for the period beginning July 1, 1986, and ending December 31, 1986, be charged 2 times the surcharge otherwise applicable under subsection (d); and

"(ii) on or after January 1, 1987, any low-level radioactive waste generated within such region or non-member State may be denied access to the regional disposal facilities referred to in paragraphs (1) through (3) of subsection (b).

"(B) BY JANUARY 1, 1988.—If any non-sited compact region or non-member State fails to comply with paragraph (1)(B)—

"(i) any generator of low-level radioactive waste within such region or non-member State shall—

"(I) for the period beginning January 1, 1988, and ending June 30, 1988, be charged 2 times the surcharge otherwise applicable under subsection (d); and

"(II) for the period beginning July 1, 1988, and ending December 31, 1988, be charged 4 times the surcharge otherwise applicable under subsection (d); and

"(ii) on or after January 1, 1989, any low-level radioactive waste generated within such region or non-member State may be denied access to the regional disposal facilities referred to in paragraphs (1) through (3) of subsection (b).

"(C) BY JANUARY 1, 1990.—If any non-sited compact

region or non-member State fails to comply with paragraph (1)(C), any low-level radioactive waste generated within such region or non-member State may be denied access to the regional disposal facilities referred to in paragraphs (1) through (3) of subsection (b).

"(D) BY JANUARY 1, 1992.—If any non-sited compact region or non-member State fails to comply with paragraph (1)(D), any generator of low-level radioactive waste within such region or non-member State shall, for the period beginning January 1, 1992 and ending upon the filing of the application described in paragraph (1)(D), be charged 3 times the surcharge otherwise applicable under subsection (d).

"(3) DENIAL OF ACCESS.—No denial or suspension of access to a regional disposal facility under paragraph (2) may be based on the source, class, or type of low-level radioactive waste.

"(4) RESTORATION OF SUSPENDED ACCESS; PENALTIES FOR FAILURE TO COMPLY.—Any access to a regional disposal facility that is suspended under paragraph (2) shall be restored after the non-sited compact region or non-member State involved complies with such requirement. Any payment of surcharge penalties pursuant to paragraph (2) for failure to comply with the requirements of subsection (e) shall be terminated after the non-sited compact region or non-member State involved complies with such requirements.

"(f)(1) ADMINISTRATION.—Each State and compact commission in which a regional disposal facility referred to in paragraphs (1) through (3) of subsection (b) is located shall have authority—

"(A) to monitor compliance with the limitations, allocations, and requirements established in this section; and

"(B) to deny access to any non-Federal low-level radioactive waste disposal facilities within its borders to any low-level radioactive waste that—

"(i) is in excess of the limitations or allocations established in this section; or

"(ii) is not required to be accepted due to the failure of a compact region or State to comply with the requirements of subsection (e)(1).

"(2) AVAILABILITY OF INFORMATION DURING INTERIM ACCESS PERIOD.—

"(A) The States of South Carolina, Washington, and Nevada may require information from disposal facility operators, generators, intermediate handlers, and the Department of Energy that is reasonably necessary to monitor the availability of disposal capacity, the use and assignment of allocations and the applicability of surcharges. South Carolina. Washington. Nevada.

"(B) The States of South Carolina, Washington, and Nevada may, after written notice followed by a period of at least 30 days, deny access to disposal capacity to any generator or intermediate handler who fails to provide information under subparagraph (A). South Carolina. Washington. Nevada.

"(C) PROPRIETARY INFORMATION.—

"(i) Trade secrets, proprietary and other confidential

information shall be made available to a State under this subsection upon request only if such State—

"(I) consents in writing to restrict the dissemination of the information to those who are directly involved in monitoring under subparagraph (A) and who have a need to know;

"(II) accepts liability for wrongful disclosure; and

"(III) demonstrates that such information is essential to such monitoring.

"(ii) The United States shall not be liable for the wrongful disclosure by any individual or State of any information provided to such individual or State under this subsection.

Prohibition. Government organization and employees. Commerce and trade.

"(iii) Whenever any individual or State has obtained possession of information under this subsection, the individual shall be subject to the same provisions of law with respect to the disclosure of such information as would apply to an officer or employee of the United States or of any department or agency thereof and the State shall be subject to the same provisions of law with respect to the disclosure of such information as would apply to the United States or any department or agency thereof. No State or State officer or employee who receives trade secrets, proprietary information, or other confidential information under this Act may be required to disclose such information under State law.

"(g) NONDISCRIMINATION.—Except as provided in subsections (b) through (e), low-level radioactive waste disposed of under this section shall be subject without discrimination to all applicable legal requirements of the compact region and State in which the disposal facility is located as if such low-level radioactive waste were generated within such compact region.

42 USC 2021f.

"SEC. 6. EMERGENCY ACCESS.

Health. Safety. Defense and national security.

"(a) IN GENERAL.—The Nuclear Regulatory Commission may grant emergency access to any regional disposal facility or non-Federal disposal facility within a State that is not a member of a compact for specific low-level radioactive waste, if necessary to eliminate an immediate and serious threat to the public health and safety or the common defense and security. The procedure for granting emergency access shall be as provided in this section.

"(b) REQUEST FOR EMERGENCY ACCESS.—Any generator of low-level radioactive waste, or any Governor (or, for any State without a Governor, the chief executive officer of the State) on behalf of any generator or generators located in his or her State, may request that the Nuclear Regulatory Commission grant emergency access to a regional disposal facility or a non-Federal disposal facility within a State that is not a member of a compact for specific low-level radioactive waste. Any such request shall contain any information and certifications the Nuclear Regulatory Commission may require.

Health. Safety. Defense and national security.

"(c) DETERMINATION OF NUCLEAR REGULATORY COMMISSION.—

"(1) REQUIRED DETERMINATION.—Not later than 45 days after receiving a request under subsection (b), the Nuclear Regulatory Commission shall determine whether—

"(A) emergency access is necessary because of an imme-

diate and serious threat to the public health and safety or the common defense and security; and

"(B) the threat cannot be mitigated by any alternative consistent with the public health and safety, including storage of low-level radioactive waste at the site of generation or in a storage facility obtaining access to a disposal facility by voluntary agreement, purchasing disposal capacity available for assignment pursuant to section 5(c) or ceasing activities that generate low-level radioactive waste. *Ante*, p. 1846.

"(2) REQUIRED NOTIFICATION.—If the Nuclear Regulatory Commission makes the determinations required in paragraph (1) in the affirmative, it shall designate an appropriate non-Federal disposal facility or facilities, and notify the Governor (or chief executive officer) of the State in which such facility is located and the appropriate compact commission that emergency access is required. Such notification shall specifically describe the low-level radioactive waste as to source, physical and radiological characteristics, and the minimum volume and duration, not exceeding 180 days, necessary to alleviate the immediate threat to public health and safety or the common defense and security. The Nuclear Regulatory Commission shall also notify the Governor (or chief executive officer) of the State in which the low-level radioactive waste requiring emergency access was generated that emergency access has been granted and that, pursuant to subsection (e), no extension of emergency access may be granted absent diligent State action during the period of the initial grant.

Prohibition.

"(d) TEMPORARY EMERGENCY ACCESS.—Upon determining that emergency access is necessary because of an immediate and serious threat to the public health and safety or the common defense and security, the Nuclear Regulatory Commission may at its discretion grant temporary emergency access, pending its determination whether the threat could be mitigated by any alternative consistent with the public health and safety. In granting access under this subsection, the Nuclear Regulatory Commission shall provide the same notification and information required under subsection (c). Absent a determination that no alternative consistent with the public health and safety would mitigate the threat, access granted under this subsection shall expire 45 days after the granting of temporary emergency access under this subsection.

Health.
Safety.
Defense and national security.

"(e) EXTENSION OF EMERGENCY ACCESS.—The Nuclear Regulatory Commission may grant one extension of emergency access beyond the period provided in subsection (c), if it determines that emergency access continues to be necessary because of an immediate and serious threat to the public health and safety or the common defense and security that cannot be mitigated by any alternative consistent with the public health and safety, and that the generator of low-level radioactive waste granted emergency access and the State in which such low-level radioactive waste was generated have diligently though unsuccessfully acted during the period of the initial grant to eliminate the need for emergency access. Any extension granted under this subsection shall be for the minimum volume and duration the Nuclear Regulatory Commission finds necessary to eliminate the immediate threat to public health and safety or the

Health.
Safety.
Defense and national security.

common defense and security, and shall not in any event exceed 180 days.

"(f) RECIPROCAL ACCESS.—Any compact region or State not a member of a compact that provides emergency access to non-Federal disposal facilities within its borders shall be entitled to reciprocal access to any subsequently operating non-Federal disposal facility that serves the State or compact region in which low-level radioactive waste granted emergency access was generated. The compact commission or State having authority to approve importation of low-level radioactive waste to the disposal facility to which emergency access was granted shall designate for reciprocal access an equal volume of low-level radioactive waste having similar characteristics to that provided emergency access.

"(g) APPROVAL BY COMPACT COMMISSION.—Any grant of access under this section shall be submitted to the compact commission for the region in which the designated disposal facility is located for such approval as may be required under the terms of its compact. Any such compact commission shall act to approve emergency access not later than 15 days after receiving notification from the Nuclear Regulatory Commission, or reciprocal access not later than 15 days after receiving notification from the appropriate authority under subsection (f).

Prohibitions.

"(h) LIMITATIONS.—No State shall be required to provide emergency or reciprocal access to any regional disposal facility within its borders for low-level radioactive waste not meeting criteria established by the license or license agreement of such facility, or in excess of the approved capacity of such facility, or to delay the closing of any such facility pursuant to plans established before receiving a request for emergency or reciprocal access. No State shall, during any 12-month period, be required to provide emergency or reciprocal access to any regional disposal facility within its borders for more than 20 percent of the total volume of low-level radioactive waste accepted for disposal at such facility during the previous calendar year.

"(i) VOLUME REDUCTION AND SURCHARGES.—Any low-level radioactive waste delivered for disposal under this section shall be reduced in volume to the maximum extent practicable and shall be subject to surcharges established in this Act.

"(j) DEDUCTION FROM ALLOCATION.—Any volume of low-level radioactive waste granted emergency or reciprocal access under this section, if generated by any commercial nuclear power reactor, shall be deducted from the low-level radioactive waste volume allocable under section 5(c).

Ante, p. 1846.
Prohibition.

"(k) AGREEMENT STATES.—Any agreement under section 274 of the Atomic Energy Act of 1954 (42 U.S.C. 2021) shall not be applicable to the determinations of the Nuclear Regulatory Commission under this section.

42 USC 2021g.

"SEC. 7. RESPONSIBILITIES OF THE DEPARTMENT OF ENERGY.

"(a) FINANCIAL AND TECHNICAL ASSISTANCE.—The Secretary shall, to the extent provided in appropriations Act, provide to those compact regions, host States, and nonmember States detemined by the

Secretary to require assistance for purposes of carrying out this Act—

"(1) continuing technical assistance to assist them in fulfilling their responsibilities under this Act. Such technical assistance shall include, but not be limited to, technical guidelines for site selection, alternative technologies for low-level radioactive waste disposal, volume reduction options, management techniques to reduce low-level waste generation, transportation practices for shipment of low-level wastes, health and safety considerations in the storage, shipment and disposal of low-level radioactive wastes, and establishment of a computerized database to monitor the management of low-level radioactive wastes; and Science and technology. Transportation. Health. Safety.

"(2) through the end of fiscal year 1993, financial assistance to assist them in fulfilling their responsibilities under this Act.

"(b) REPORTS.—The Secretary shall prepare and submit to the Congress on an annual basis a report which (1) summarizes the progress of low-level waste disposal siting and licensing activities within each compact region, (2) reviews the available volume reduction technologies, their applications, effectiveness, and costs on a per unit volume basis, (3) reviews interim storage facility requirements, costs, and usage, (4) summarizes transportation requirements for such wastes on an inter- and intra-regional basis, (5) summarizes the data on the total amount of low-level waste shipped for disposal on a yearly basis, the proportion of such wastes subjected to volume reduction, the average volume reduction attained, and the proportion of wastes stored on an interim basis, and (6) projects the interim storage and final disposal volume requirements anticipated for the following year, on a regional basis. Science and technology. Transportation.

"SEC. 8. ALTERNATIVE DISPOSAL METHODS. 42 USC 2021h.

"(a) Not later than 12 months after the date of enactment of the Low-Level Radioactive Waste Policy Amendments Act of 1985, the Nuclear Regulatory Commission shall, in consultation with the States and other interested persons, identify methods for the disposal of low-level radioactive waste other than shallow land burial, and establish and publish technical guidance regarding licensing of facilities that use such methods. *Ante*, p. 1842.

"(b) Not later than 24 months after the date of enactment of the Low-Level Radioactive Waste Policy Amendments Act of 1985, the Commission shall, in consultation with the States and other interested persons, identify and publish all relevant technical information regarding the methods identified pursuant to subsection (a) that a State or compact must provide to the Commission in order to pursue such methods, together with the technical requirements that such facilities must meet, in the judgment of the Commission, if pursued as an alternative to shallow land burial. Such technical information and requirements shall include, but need not be limited to, site suitability, site design, facility operation, disposal site closure, and environmental monitoring, as necessary to meet the performance objectives established by the Commission for a licensed low-level radioactive waste disposal facility. The Commission shall specify and publish such requirements in a manner and

form deemed appropriate by the Commission.

42 USC 2021i. "SEC. 9. LICENSING REVIEW AND APPROVAL.

"In order to ensure the timely development of new low-level radioactive waste disposal facilities, the Nuclear Regulatory Commission or, as appropriate, agreement States, shall consider an application for a disposal facility license in accordance with the laws applicable to such application, except that the Commission and the agreement state shall—

"(1) not later than 12 months after the date of enactment of the Low-Level Radioactive Waste Policy Amendments Act of 1985, establish procedures and develop the technical capability for processing applications for such licenses; *Ante*, p. 1842.

"(2) to the extent practicable, complete all activities associated with the review and processing of any application for such a license (except for public hearings) no later than 15 months after the date of receipt of such application; and

"(3) to the extent practicable, consolidate all required technical and environmental reviews and public hearings.

"SEC. 10. RADIOACTIVE WASTE BELOW REGULATORY CONCERN.

"(a) Not later than 6 months after the date of enactment of the Low-Level Radioactive Waste Policy Amendments Act of 1985, the Commission shall establish standards and procedures, pursuant to existing authority, and develop the technical capability for considering and acting upon petitions to exempt specific radioactive waste streams from regulation by the Commission due to the presence of radionuclides in such waste streams in sufficiently low concentrations or quantities as to be below regulatory concern.

"(b) The standards and procedures established by the Commission pursuant to subsection (a) shall set forth all information required to be submitted to the Commission by licensees in support of such petitions, including, but not limited to—

"(1) a detailed description of the waste materials, including their origin, chemical composition, physical state, volume, and mass; and

"(2) the concentration or contamination levels, half-lives, and identities of the radionuclides present.

Health. Safety. Regulation.

Such standards and procedures shall provide that, upon receipt of a petition to exempt a specific radioactive waste stream from regulation by the Commission, the Commission shall determine in an expeditious manner whether the concentration or quantity of radionuclides present in such waste stream requires regulation by the Commission in order to protect the public health and safety. Where the Commission determines that regulation of a radioactive waste stream is not necessary to protect the public health and safety, the Commission shall take such steps as may be necessary, in an expeditious manner, to exempt the disposal of such radioactive waste from regulation by the Commission."

Appendix E: Regulations to Implement the LLRW Management Plan

345 CMR 1.00: LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT PLAN

Sections

General Provisions

1.01 Purpose and Statutory Authority

(1) Purpose. 345 CMR 1.00 set forth the regulatory components of or pertaining to the Low-Level Radioactive Waste Management Plan. These and all other regulations of the Board shall be interpreted so as to ensure open and fair procedures and comprehensive planning, and to protect public health, safety, and the environment.

(2) Statutory Authority. 345 CMR 1.00 are promulgated pursuant to M.G.L. c.111H, ss.4, 11, and 12.

1.02 Definitions

For the purpose of 345 CMR 1.00, the following definitions shall apply unless the context or subject matter requires a different interpretation:

"Activity," the rate of decay of radioactive material.

"Affected Community," a community, other than a site community, which is identified in an environmental impact report prepared pursuant to M.G.L. c.111H, s.30, and can be expected to experience significant impacts as a result of the location, development, operation, closure, post-closure observation and maintenance, or institutional control of a facility.

"Board," the Low-Level Radioactive Waste Management Board established in M.G.L. c.111H, s.2, which is responsible for planning and effecting the management of low-level radioactive waste in the Commonwealth.

"Broker," a person engaged in the business of arranging for the collection, transportation, treatment, storage or disposal of low-level radioactive waste.

"Candidate Site," a site, identified in accordance with the procedures established in M.G.L. c.111H, s.20 which will be the subject of detailed site characterization as part of the process to select any superior site.

"Candidate Site Community," a community in which is located all or any part of a candidate site.

"Chelating Agent" means certain organic compounds capable of forming (multiple) coordinate bonds with metals through two or more atoms of the organic compound, typically resulting in enhanced

thermodynamic stability in solution and greatly altered behavior of the metal ions. Examples include amine polycarboxylic acids (e.g., EDTA, DTPA), and polycarboxylic acids (e.g., citric acid, carbolic acid and glucinic acid).

"Chief Elected Official," the mayor of any city, the chairman of the board of selectmen in any town.

"Chief Executive Officer," the city manager in any city having a city manager, the mayor in any other city, the town manager in any town having a town manager, the chairman of the board of selectmen in any other town.

"Closure," the permanent termination of low-level radioactive waste acceptance at a facility, including closure prior to the scheduled closing date, and the implementation of a closure plan.

"Community," a city or town of the Commonwealth.

"Community Compensation," any money, thing of value, or economic benefit conferred by an operator or the Board on any site or neighboring community under the terms and conditions specified in a comprehensive operating contract executed pursuant to M.G.L. c.111H, s.33.

"Community Supervisory Committee," a committee, established pursuant to M.G.L. c.111H, s.21 to facilitate the participation of a community, in which a candidate site is located, in the activities established by this chapter.

"Comprehensive Operating Contract," a contract entered into by an operator and the Board pursuant to M.G.L. c.111H, s.33 which specifies the community compensation to be provided by the operator or the Board.

"Container" means the primary vessel, exclusive of other reusable shielding or other packaging materials, in which waste is placed and received for treatment, storage, or disposal; or the vessel into which waste is repackaged for storage or disposal and potential retrieval.

"Contingent Liability Account," an account within the Low Level Radioactive Waste Trust Fund established pursuant to M.G.L. c.111H, s.41 for the purpose of compensating for injuries to persons, land or property, pursuant to M.G.L. c.111H, s.9, if no other funds, insurance, tort compensation or other means of satisfying a damage judgment or settlement are available.

"Curie," a unit of activity which represents the quantity of any radionuclide that undergoes 37 billion disintegrations per second (3.7×10^{10} d/s).

"Days," calendar days; provided that in computing time periods such periods shall exclude the day of the event which starts the period running, and further provided that if the last day of a period falls on a Sunday, legal holiday or declared state of emergency day, such period shall be extended to the close of business on the next business day.

"Decommissioning," the safe removal from service of an activity involving radioactive materials or waste, and the reduction of residual radioactivity to a level that permits release of the property for unrestricted use and termination of the license.

"DEP," the Department of Environmental Protection.

"Detailed Site Characterization," the on-site investigatory and analytical step of site selection established in M.G.L. c.111H, s.23, and conducted prior to the selection of any superior site.

"Determinable Property Interest," an interest in property created with a special limitation that delimits the duration of the interest.

"Development," all activities undertaken with respect to a low-level radioactive waste facility during the period commencing with the selection of any superior site pursuant to M.G.L. c.111H, s.23 and continuing until the commencement of facility operation pursuant to M.G.L. c.111H, s.39.

"Disposal," the isolation of low-level radioactive waste from the biosphere inhabited by human beings and their food chains.

"DPH," the Department of Public Health.

"Environmental Monitoring Program," a monitoring program established by DPH, after consultation with DEP and the board of health of each site community, pursuant to M.G.L. c.111H, s.36 for the purpose of collecting and analyzing environmental data prior to construction and throughout the construction, operation, closure, post-closure observation and maintenance, and institutional control of a facility.

"Facility," a parcel of land, together with the structures, equipment and improvements thereon or appurtenant thereto, which, pursuant to M.G.L. c.111H, is being developed, is used, or has been used for the treatment, storage or disposal of low-level radioactive waste. A "facility" does not include any property used for temporary storage of low-level radioactive waste in sealed containers by a broker.

"Facility License," a license to operate a facility Issued by DPH pursuant to M.G.L. c.111H, s.31, or a license issued for a facility by the U.S. Nuclear Regulatory Commission.

"Financial Risk Assessment," a comprehensive evaluation of the potential hazards associated with the operation, closure, post-closure observation and maintenance, and Institutional control of a storage, treatment or disposal facility, the financial risks associated with these potential hazards and the financial mechanisms necessary to indemnify or insure against such risks.

"Generator," a person, including a broker, who produces low level radioactive waste.

"Half-Life," the time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form.

"Hazardous Waste," a waste, or combination of wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may cause, or significantly contribute to an Increase In mortality or an Increase in serious irreversible, or Incapacitating reversible illness or pose a substantial present or potential hazard to human health, safety, or welfare or to the environment when improperly treated, stored, transported, used or disposed of, or otherwise managed, however, not to Include solid or dissolved materials In domestic sewage, or solid or dissolved materials in irrigation return flows or industrial discharges which are point sources subject to permits under section 402 of the Federal Water Pollution Control Act of 1967 as amended, or source, special nuclear, or by product materials as defined by the Atomic Energy Act of 1954.

"Institutional Control," the continued observation, monitoring and care of a facility following transfer of the facility license from the operator to the Board.

"Institutional Control Account," an account within the Low Level Radioactive Waste Trust Fund established in M.G.L. c.111H, s.41 for the purpose of paying Institutional control costs pursuant to

M.G.L. c.111H, ss.9 and 47.

"Interim Storage," storage of low-level radioactive waste for a period of five years or less, or as determined by the licensing agency.

"Isotopes," nuclides with the same number of protons but differing numbers of neutrons in the nucleus.

"Licensee," a person holding a license issued pursuant to Part C of 105 CMR 120.000 by DPH or a license issued by the U.S. Nuclear Regulatory Commission to transfer, acquire, own, possess or use quantities of, or devices or equipment utilizing, radioactive material.

"Low-Level Radioactive Waste ('LLRW')" or "waste," radioactive material that (1) is neither high-level waste, nor spent nuclear fuel, nor byproduct material as defined in section 11(e)(2) of the Atomic Energy Act of 1954, as amended, 42 U.S.C. s. 2014(e); and (2) is classified by the Federal Government as low-level radioactive waste, but not including waste which remains a Federal responsibility, as designated in s.3(b) of the Low-Level Radioactive Waste Policy Act, as amended, 42 U.S.C. s.2021c(b), as in effect as of December 8, 1987.

"Low-Level Radioactive Waste Trust Fund," a trust fund established pursuant to M.G.L. c.10, s.35H which shall consist of surcharges collected from users of the low-level radioactive waste facility in an amount determined by the Board on an annual basis, which shall be used to meet the obligations set forth in M.G.L. c.111H, ss.9 and 47.

"Management," the storage, packaging, treatment, transportation, or disposal, where applicable, of low-level radioactive waste.

"Management Plan," the Low-Level Radioactive Waste Management Plan adopted by the Board pursuant to M.G.L. c.111H, s.12 to provide for the safe and efficient management of low-level radioactive waste.

"Manifest," a detailed record of the characteristics and quantities of packaged waste as presented for transportation, treatment, storage, or disposal which usually accompanies waste transfers for these purposes.

"Mixed Waste," low-level radioactive waste containing material that either
- (a) is listed in 310 CMR 30.131 through 30.136; or
- (b) causes the waste to exhibit any of the characteristics identified in 310 CMR 30.120.

"Monitoring," observing and making measurements to provide data on a facility, its site, its surrounding environment, and its health and environmental impacts.

"Neighboring Community," a community, other than a site community, which, according to the most recent decennial census conducted pursuant to M.G.L. c.9, s.7, has at least twenty percent (20%) of its population residing within three miles of any superior site.

"Nuclide," atoms characterized by their atomic number (number of protons) and their mass.

"Operation," the control, supervision or implementation of the actual physical activities involved in the acceptance, storage, treatment, disposal or monitoring of low-level radioactive waste at a facility and the maintenance of the facility and any other responsibilities of the operation pertaining to the facility.

"Operator," a person designated in accordance with the procedures established in M.G.L. c.111H, ss.22 and 27 to develop and operate a low-level radioactive waste facility.

"Performance assessment," the process of analyzing the performance of a facility, usually using computer modeling, in order to evaluate its ability to meet the requirements of 1.05 CMR 120.811 through 120.816.

"Person," any agency or political subdivision of the Federal Government or the Commonwealth, or of any state, any public or private corporation or authority, individual, firm, joint stock company, partnership, association, trust, estate, institution or other entity, and any officer, employee or agent of such person, and any group of such persons.

"Possible Location," a location, identified in accordance with the procedures established in M.G.L. c.111H, s.20, which will be the subject of preliminary characterization.

"Post-closure Observation and Maintenance," the active monitoring and maintenance of a facility which has been closed in preparation for transfer of the facility's license from the operator to the Board.

"Preliminary Characterization," the investigatory and analytical step established in M.G.L. c.111H, s.20, and conducted prior to the identification of candidate sites.

"Professional Training," the level of academic or on-the-job training generally recognized as adequate to qualify a person to be employed in a discipline.

"Property Value Protection District," an area of land, identified by the Board, after consultation with the community supervisory committee, which includes all land within one-half mile of the waste management area of a facility and may include other land not more than one mile from the waste management area of the facility.

"Public Interest," the common welfare, convenience, benefit, and necessity of the people of the Commonwealth, including public health, safety, and the environment.

"Public Meeting," a public hearing, satisfying the requirements of M.G.L. c.30A, s.2, in which an agency presents information, responds to inquiries, and hears testimony of interested persons.

"Public Participation Coordinator," the person appointed pursuant to M.G.L. c.111H, s.6 to encourage and facilitate the participation of interested persons in all of the processes established in or pursuant to the Act, and to carry out the other duties prescribed in the Act.

"Radioactive Materials," any solid, liquid, or gas which emits radiation spontaneously.

"Radioactivity," the transformation of unstable atomic nuclei by the emission of radiation.

"Radionuclide," an isotope that eventually undergoes spontaneous disintegration, with the emission of radiation.

"Remediation," the planning, design, and implementation of appropriate means of assessment and solution of a contamination problem.

"Retrievable," able to recover waste in an intact container without substantial destruction of the engineered barriers surrounding the waste containers.

"Retrieval," the recovery of waste in an intact container.

"Secretary," the Secretary of the Executive Office of Environmental Affairs.

"Shallow Land Burial," a land disposal method that relies on the site's natural characteristics as the primary barrier for isolation of the waste.

"Site Community," the community in which is located all or any part of any superior site.

"Source Minimization," minimizing the volume of radioactivity of low-level radioactive waste prior to its generation by such methods as: (1) avoiding unnecessary contamination of items during the use of radioactive materials; (2) carefully segregating radioactive waste from non-radioactive trash; or (3) substituting non-radioactive isotopes or radioisotopes with shorter half-lives where practicable.

"Storage," the holding of low-level radioactive waste for treatment or disposal.

"Storage for Decay," a procedure in which low-level radioactive waste with a relatively short half-life is held for natural radioactive decay in compliance with applicable federal and state regulations.

"Superior Site," any site selected by the Board, after detailed site characterization, pursuant to M.G.L. c.111H, s.23.

"Treatment," any method, technique, or process, including source minimization, volume minimization and storage for decay, designed to change the physical, radioactive, chemical or biological characteristics or composition of low-level radioactive waste in order to render such waste safer for management, amenable for recovery, convertible to another usable material or reduced in volume.

"Volume Minimization," treatment of low-level radioactive waste after its generation in order to minimize the physical dimensions of the waste and the space required for storage or disposal.

"Waste Form," those physical and chemical characteristics of LLRW of primary importance in influencing its stability in a storage or disposal environment.

1.03 Board Representing the Public Interest

(1) The Board shall be responsible for planning and effecting the management of low-level radioactive waste in the Commonwealth in accordance with M.G.L. c.111H.

(2) The Board shall consist of members who, by reason of their office, experience, background and professional training, can act in the public interest.

1.04 Management Plan Adoption, Review and Revision

(1) The Low-Level Radioactive Waste Management Plan, as approved by vote of the Low-Level Radioactive Waste Management Board on December 22, 1993, is hereby adopted by regulation.

(2) The Management Plan shall be reviewed annually by the Board and revised as necessary.

(3) A public hearing satisfying the requirements of M.G.L. c.30A, s.2 shall be required prior to the amendment or repeal of the Management Plan.

1.05 Public Participation

(1) The Board shall develop and implement a Public Participation Plan which identifies citizen involvement policies and procedures. Such plan shall include, but not be limited to:
   (a) a statement of goals; and
   (b) procedures to accomplish the goals.

(2) The recommendations of the Public Participation Coordinator, made pursuant to M.G.L. c.111H, s.6, shall be implemented to the extent feasible in order:
   (a) to ensure appropriate public participation as the Management Plan and any regulations are developed pursuant to M.G.L. c.111H;
   (b) to ensure that adequate information concerning the Management Plan and any regulations adopted pursuant to M.G.L. c.111H is available;
   (c) to facilitate the conduct of public meetings and other opportunities for public review and comment; and
   (d) to ensure that public concerns are identified and addressed throughout the implementation of the Management Plan and any regulations adopted pursuant to M.G.L. c.111H.

(3) Except as permitted by M.G.L. c.66, s.10, no studies relevant to the implementation of the Management Plan shall be kept confidential by the Board.

1.06 Management Plan Consistency Review: The Board shall evaluate each request to DPH by a radioactive materials licensee for a license amendment to determine the consistency of such amendment with the Management Plan, and shall make its recommendation known to DPH.

1.07 Waivers and Severability

(1) Waiver
   (a) The Board shall not waive the application of the site selection criteria adopted by DEP pursuant to M.G.L. c.111H, s.14(d).
   (b) The Board may waive the application of any section of 345 CMR 1.00 if it finds that:
      1) public health, safety, and the environment will be protected;
      2) strict application of the section to be waived would undermine the public interest;
      3) specific substitute requirements can be adopted which will result in the substantial protection of the process established in M.G.L. c.111H and the rights of persons affected by the action; and
      4) the action made possible by the waiver will not violate the provisions of M.G.L. c.111H or any other state or federal law.

(2) Severability. If any provision of 345 CMR 1.00 is held to be invalid, such invalidity shall not affect the provisions of the application thereof not specifically held invalid.

Classification System

1.11 Classification System Requirements: The Board's classification system for all LLRW generated, treated or disposed of in the Commonwealth shall be compatible with federal requirements, set forth in 345 CMR 1.12, but shall provide further for total hazard classification, as set forth in 345 CMR 1.13.

1.12 Federal Classification of Radioactive Waste for Near-Surface Disposal

(1) Considerations. Determination of the classification of radioactive waste involves two considerations. First, consideration must be given to the concentration of longlived radionuclides (and their shorter-lived precursors) whose potential hazard will persist long after such precautions as institutional controls, improved waste form, and deeper disposal have ceased to be effective. These precautions delay the time when long-lived radionuclides could cause exposures. In addition, the magnitude of the potential dose is limited by the concentration and availability of the radionuclide at the time of exposure. Second, consideration must be given to the concentration of shorter-lived radionuclides for which requirements on institutional controls, waste form, and disposal methods are effective.

(2) Classes of waste

(a) Class A waste is waste that is usually segregated from other waste classes at the disposal site. The physical form and characteristics of Class A waste must meet the minimum requirements set forth in 105 CMR 120.248(a). If Class A waste also meets the stability requirements set forth in 105 CMR 120.248(a), it is not necessary to segregate the waste for disposal.

(b) Class B waste is waste that must meet more rigorous requirements on waste form to ensure stability after disposal. The physical form and characteristics of Class B waste must meet both the minimum and stability requirements set forth in 105 CMR 120.248.

(c) Class C waste is waste that not only must meet more rigorous requirements on waste form to ensure stability but also requires additional measures at the disposal facility to protect against inadvertent intrusion. The physical form and characteristics of Class C waste must meet both the minimum and stability requirements set forth in 105 CMR 120.248.

(3) Classification Determined by Long-Lived Radionuclides. If radioactive waste contains only radionuclides listed in Table 1.12A, classification shall be determined as follows:

(a) If the concentration does not exceed 0.1 times the value in Table 1.12A, the waste is Class A.

(b) If the concentration exceeds 0.1 times the value in Table 1.12A but does not exceed the value in Table 1.12A, the waste is Class C.

(c) If the concentration exceeds the value in Table 1.12A, the waste is not generally acceptable for near-surface disposal.

(d) For waste containing mixtures of radionuclides listed in Table 1.12A, the total concentration shall be determined by the sum of fractions rules described in paragraph (7) of this section.

(4) Classification Determined by Short-Lived Radionuclides. If radioactive waste does not contain any of the radionuclides listed in Table 1.12A, classification shall be determined based on the concentrations shown in Table 1.12B. However, as specified in paragraph (a)(6) of this section, if radioactive waste does not contain any nuclides listed in either Table 1.12A or 1.12B, it is Class A.

(a) If the concentration does not exceed the value in Column 1, the waste is Class A.

(b) If the concentration exceeds the value in column 1, but does not exceed the value in Column 2, the waste is class B.

(c) If the concentration exceeds the value in Column 2, but does not exceed the value in Column 3, the waste is Class C.

Table 1.12A	
Radionuclide	Concentration, curies per cubic meter
C-14	8
C-14 in activated metal	80
Ni-59 in activated metal	220
Nb-94 in activated metal	0.2
Tc-99	3
I-129	0.08
Alpha emitting transuranic nuclides with half-life greater than five years	100*
Pu-241	3,500*
Cm-242	20,000*

* Units are nanocuries per gram.

Table 1.12B			
	Concentration, curies per cubic meter		
Radionuclide	Col. 1	Col. 2	Col. 3
Total of all nuclides with less than 5 year half life	700	*	*
H-3	40	*	*
Co-60	700	*	*
Ni-63	3.5	70	700
Ni-63 in activated metal	35	150	7,000
Sr-90	0.04	150	7,000
Cs-137	*	44	4,600

* There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling, and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other nuclides in Table 1.12B determine the waste to be Class C independent of these nuclides.

(d) If the concentration exceeds the value in Column 3, the waste is not generally acceptable for near-surface disposal.

(e) For wastes containing mixtures of the nuclides listed in Table 1.12B, the total concentration shall be determined by the sum of fractions rule described in paragraph (7) of this section.

(5) Classification Determined by Long- and Short-Lived Radionuclides. If radioactive waste contains a mixture of radionuclides, some of which are listed in Table 1.12A, and some of which are listed in Table 1.12B, classification shall be determined as follows:

(a) If the concentration of a nuclide listed in Table 1.12A does not exceed 0.1 times the value listed in Table 1.12A, the class shall be that determined by the concentration of nuclides listed in Table 1.12B.

(b) If the concentration of a nuclide listed in Table 1.12A exceeds 0.1 times the value listed in Table 1.12A but does not exceed the value in Table 1.12A, the waste shall be Class C, provided the concentration of nuclides listed in Table 1.12B does not exceed the value shown in Column 3 of Table 1.12B.

(6) Classification of Wastes with Radionuclides Other Than Those Listed in Tables 1.12A and 1.12B. If radioactive waste does not contain any nuclides listed in either Table 1.12A or 1.12B, it is Class A.

(7) The Sum of the Fractions Rule for Mixtures of Radionuclides. For determining classification for waste that contains a mixture of radionuclides, it is necessary to determine the sum of fractions by dividing each nuclide's concentration by the appropriate limit and adding the resulting values. The appropriate limits must all be taken from the same column of the same table. The sum of the fractions for the column must be less than 1.0 if the waste class is to be determined by that column. Example: A waste contains Sr-90 in a concentration of 50 Ci/m3 and Cs-137 in a concentration of 22 Ci/m3. Since the concentrations both exceed the values In Column 1, Table 1.12B, they must be compared to Column 2 values. For Sr-90 fraction 50/150=0.33; for Cs-137 fraction, 22/44=0.5; the sum of the fractions =0.83. Since the sum is less than 1.0, the waste is Class B.

(8) Determination of Concentrations in Wastes. The concentration of a radionuclide may be determined by indirect methods such as use of scaling factors which relate the inferred concentration of one radionuclide to another that is measured, or radionuclide material accountability, if there is reasonable assurance that the indirect methods can be correlated with actual measurements. The concentration of a radionuclide may be averaged over the volume of the waste, or weight of the waste if the units are expressed as nanocuries per gram.

1.13 Massachusetts Total Hazard Classification System

(1) The data to be derived from a total hazard classification system for Massachusetts shall be used in tracking waste generation and in the siting, design, performance assessment, licensing, closure, monitoring, and possible remediation of future facilities. They may also be used to make assessments and decisions on other waste management needs, such as the need for additional waste minimization and other waste treatment steps and for negotiation of agreements, contracts, or interstate compacts with other states.

(2) The classification system shall consist of:

(a) A survey, or data acquisition tool, to allow detailed characterization of each waste stream;

(b) An inventory, or data compilation tool;

(c) A codification system to allow categorization, classification, and data sorting;

(d) A codification system to allow identification, management, and disposal consistent with other federal and state regulations (e.g., NRC, EPA, DEP);

(e) A data manipulation and analytic tool to process and compile data by any characteristics of interest and for any need; and

(f) A classification and tracking (manifest) system to allow operation, monitoring, and remediation, if necessary, at potential storage, treatment, or disposal facilities.

(3) The Massachusetts LLRW disposal classification system shall be as set forth in Table 1.13A.

Table 1.13A

Classification for Licensed LLRW Disposal

Disposal Class	Description
AU	Class A unstable LLRW.
AS	Class A stable LLRW.
B	Class B LLRW per NRC.
C	Class C LLRW per NRC.
GTCC	Greater-than-Class-C - not suited for near-surface disposal.*
AU-H	Class A unstable LLRW sith treated RCRA/DEP hazardous waste components.
AS-H	Class A stable LLRW with treated RCRA/DEP hazardous waste components.
B-H	Class B LLRW with treated RCRA/DEP hazardous waste components.
C-H	Class C LLRW with treated RCRA/DEP hazardous waste components.
GTCC-H	Greater than Class C LLRW with treated RCRA/DEP hazardous waste components - not suitable for near-surface disposal.*

* GTCC waste is the responsibility of the federal government and is not LLRW. GTCC is classified here for tracking purposes only.

(4) The following parameters shall, where applicable to a given waste type, be collected and evaluated in the classification of LLRW:
(a) generator identification;
(b) location of waste generated - city/town;
(c) waste type;
(d) radioactivity - total activity, radioisotopic content of waste stream, specific activity, millicuries or millicuries/container for each radionuclide;
(e) container radiation levels, if applicable - range of levels and typical level for the waste stream;
(f) treatment performed on-site, volume and activity reduction achieved;
(g) physical matrix, if applicable - solidification or sorption media;
(h) EPA/DEP hazard code(s), if applicable - before and after treatment and EPA/DEP treatment employed;
(i) chelating agents - type and amounts greater than 1%;
(j) type of containers and number of each type used each year for storage or disposal - description, dimensions, full weight, disposal volume;
(k) disposal class - Massachusetts/NRC compatible classification;
(l) disposal site used;
(m) storage site used;
(n) total volume/year;
(o) volume and activity shipped to broker or processor;
(p) treatment used by broker or processor;

(q) volume and activity delivered from broker or processor for storage or disposal;
(r) broker and processor identification;
(s) volume and activity held in storage for future disposal;
(t) storage location - city/town;
(u) treatment of stored waste planned prior to disposal;
(v) expected volume, activity, and disposal class of stored waste after treatment;
(w) expected shipment date of stored waste;
(x) total volume and activity of waste stream held for decay to level not requiring licensed radioactive waste treatment or land disposal;
(y) identification of disposal techniques used other than storage for decay or licensed off-site disposal - volume and activity so managed; and
(z) termination of production of waste stream or decommissioning waste streams - date expected, type of waste, volume, activity, percent major radionuclides.

Mixed Waste

1.21 Mixed Waste Management Practice
(Reserved)

Packaging, Shipping and Transportation Requirements

1.31 Waste Transportation

(1) All waste shipments shall be packaged and transported in a manner that ensures, to the extent reasonably achievable, that waste will arrive at its destination safely, in a manner acceptable to the destination entity, without health, safety, or environmental damage and without exposing the Commonwealth to contingent liabilities.

(2) Waste shall be deemed to be available for shipment only when:
(a) Prior agreement has been reached with a destination entity licensed to receive the waste;
(b) All terms of the agreement, including any waste acceptance criteria or requirements for payment of a fee, have been complied with;
(c) All regulatory requirements governing the packaging, shipment or transportation of the waste have been complied with; and
(d) All measures appropriate to the LLRW shipment have been taken to ensure that the waste can be received safely at its destination.

1.32 Re-Entry of Waste into the Commonwealth after Shipment Out of State for Treatment

(1) The Board shall provide assurances that waste shall be permitted to re-enter the Commonwealth to be returned to its generator for storage, upon the request of out-of-state processors, with respect to all shipments of waste for treatment that satisfy the following conditions:
(a) The Board has been given prior notification of the waste shipment to be returned, indicating the chemical composition, activity and volume of the waste, the shipping destination and carrier:
(b) The generator is authorized to, and has agreed to accept the waste back within the terms of its license;
(c) The generator has executed a contract for the treatment or processing of the waste; and
(d) The waste satisfies any and all waste acceptance criteria imposed pursuant to such

contract.

(2) The provision of such assurances shall not constitute agreement to permit re-entry of the waste for purposes other than its return to the generator.

(3) Nothing In 345 CMR 1.32 or in the provision of assurances pursuant to 345 CMR 1.32 shall constitute agreement by the Board or the Commonwealth to accept possession of waste or otherwise to provide for its storage or disposal.

(4) Nothing In 345 CMR 1.32 or in the provision of assurances pursuant to 345 CMR 1.32 shall be construed as acceptance by the Commonwealth of responsibility for any losses, claims, or costs incurred in connection with, or as a result of the re-entry of the waste.

Storage Requirements

1.41 Development of Interim and Emergency Storage Plans

(1) Interim and emergency storage plans shall be developed and implemented by the Board whenever it appears that no facility is or will be available to accept waste produced In Massachusetts.

(2) The Board shall determine whether an interim or emergency storage plan will fully utilize on-site storage by generators, or instead require an interim or emergency centralized storage facility. In the event that a centralized Interim or emergency storage facility is determined to be needed, the Board shall identify a location for interim storage, after notice and an opportunity for hearing, and may apply for a facility license in accordance with the provisions of M.G.L. c.111H, s.31, as permitted by M.G.L. c.111H, s.12(b)(10), without satisfying the requirements of 345 CMR 1.82-1.88.

1.42 Loss-of-Access Contingency Plan. The Board shall develop, circulate for public and agency comment, and update as appropriate a contingency plan to ensure a coordinated state agency response to handle generators' loss of access to disposal sites.

1.43 Financial Responsibility for Repackaging. The repackaging for disposal of any waste In a storage facility developed pursuant to M.G.L. c.111H shall be the financial responsibility of the generator.

1.44 Monitoring the Storage Needs of Massachusetts Generators. The Board shall monitor the storage needs of generators.

Treatment Requirements

1.51 Monitoring the Treatment Needs of Massachusetts Generators. The Board shall monitor the treatment needs of generators.

Disposal Requirements

1.61 Retrievable Disposal Technologies

(1) Any disposal method utilized at a facility shall permit retrieval and monitoring of the waste. Except as provided in 345 CMR 1.61(3), any disposal method that satisfies this criterion may be utilized at a facility if permitted by its license, whether or not such method is listed in 345 CMR 1.61(2).

(2) Disposal methods that shall be presumed capable of satisfying the requirements of this section, under appropriate conditions, shall include:
(a) below-ground modular concrete canister disposal;
(b) below-ground vaults;
(c) mined cavity;
(d) borehole or augured holes;
(e) above-ground vaults;
(f) above-ground vaults with earthen cover;
(g) above-ground modular canisters;
(h) above-ground modular canisters with earthen cover;
(i) above ground vaults with modular canisters;
(j) a combination of these technologies.

(3) No disposal facility in the Commonwealth shall utilize:
(a) shallow land burial;
(b) hydrofracture;
(c) intermediate depth disposal; or
(d) earth-mounded concrete bunker disposal.

1.62 Monitoring the Disposal Needs of Massachusetts Generators. The Board shall monitor the disposal needs of generators.

1.63 Disposal Fees, Waste Acceptance Criteria and Surcharges

(1) Upon the issuance of a facility license pursuant to M.G.L. c.111H, s.31, and annually thereafter, until the facility license is transferred to the Board pursuant to M.G.L. c.111H, s.46, the facility operator shall pay to the Commonwealth, prior to the commencement of the fiscal year, an amount determined by DPH pursuant to M.G.L. c.111H, s.38(a).

(2) The operator shall annually submit to the Board, for approval in accordance with this section, a proposed schedule of fees and criteria for acceptance of LLRW. The operator's proposed schedule of fees shall be accompanied by:
(a) a certified audit of gross operating receipts from fees and surcharges imposed for acceptance of LLRW at the facility during the current and prior fiscal years; and
(b) a verification under oath that:
1) all compensation required to be paid by the operator to each site, neighboring and affected community by the comprehensive operating contract has been paid; and
2) all surcharges collected for the Low-Level Radioactive Waste Trust Fund have been remitted to the state treasurer in accordance with the requirements of the comprehensive operating contract executed pursuant to M.G.L. c.111H, s.33.

(3) Schedule of Fees. The schedule of fees shall:
(a) be based on the classification system set forth in 345 CMR 1.11-1.13;
(b) be designed so as to promote source minimization, volume minimization, and storage for decay by generators;
(c) establish service charges for waste shipments found not to be in compliance with applicable regulations and conditions of the facility license;
(d) be adequate to reimburse the operator for:
1) all reasonable expenses of facility development and operation, including the costs of premature facility closure and decommissioning;

2) all reasonable community compensation guaranteed to site, neighboring, and affected communities in the comprehensive operating contract executed pursuant to M.G.L. c.111H, s.33;
3) DPH's required annual payment established pursuant to this section; and
4) a reasonable profit from the operation of the facility.

(4) Waste Acceptance Criteria:
(a) The waste acceptance criteria shall:
1) be consistent with the Management Plan and based on the classification system set forth in 345 CMR 1.11-1.13;
2) be adequate to ensure proper and efficient operation of the facility;
3) be designed so as to ensure source minimization, volume minimization and storage for decay by generators in compliance with 105 CMR 120.890;
4) be designed to conserve facility resources; and
5) specify that no LLRW shall be accepted from an electric-power-generating facility if such waste requires management more stringent than the most stringent management required for any LLRW which may be accepted at the facility from another generator.
(b) In reviewing the waste acceptance criteria for a disposal facility, the Board shall evaluate
1) waste form;
2) stability; and
3) requirements for pre-treatment to enhance the ability of the facility to:
a) dispose of the waste so as to keep radiation exposures as low as reasonably achievable; and
b) be operated in a manner most protective of the public health, safety, and environment.
4) the adequacy of requirements to ensure source minimization, volume minimization, and storage for decay by generators in compliance with 105 CMR 120.890.

(5) All books and records of the operator shall be subject to audit pursuant to M.G.L. c.11, s.12.

(6) The Board, after notice and opportunity for hearing, shall:
(a) approve, modify or reject the schedule of fees and waste acceptance criteria submitted by the operator; and
(b) establish annually a schedule of surcharges for the Low-Level Radioactive Waste Trust Fund established in M.G.L. c.111H, s.41. Such surcharges shall be adequate to ensure that the contingent liability and institutional control accounts within the Low-Level Radioactive Waste Trust Fund will contain enough funds to:
1) properly maintain the facility throughout the institutional control period; and
2) provide for compensation for injuries to persons, land or property.

(7) The fees, criteria and surcharges approved or established by the Board pursuant to this section shall be imposed as conditions of acceptance of all LLRW at the facility until new or revised fees, criteria, or surcharges are approved by the Board.

Determination Of Need

1.71 Implementation of Finding of Requirement for Additional Facility Capacity

(1) Any finding that there is a requirement for additional facility capacity to meet present needs or needs anticipated to arise within the next decade shall be included in the Management Plan adopted by the Board.

(2) Any finding that there is a requirement for additional facility capacity to meet present needs or needs anticipated to arise within the next decade shall be made only after review of both out-of-state and in-state options for short-term and long-range waste management. Such options may include, but need not be limited to:
(a) the out-of-state disposal of LLRW;
(b) the on-site storage of LLRW on the premises where it is generated for five years or longer, if permitted by DPH or the NRC;
(c) a centralized storage facility sited within the Commonwealth; and
(d) a disposal facility sited within the Commonwealth.

<u>1.72 Storage Facility</u>

(1) The Board hereby finds that there is no requirement for additional storage facility capacity to meet present needs, but that there is a requirement for additional storage facility capacity to meet needs anticipated to arise within the next decade.

(2) No determination to proceed with centralized storage facility site selection pursuant to M.G.L. c.111H, s.17 shall be made unless the Board finds that reliance on future on-site storage of LLRW is not a satisfactory management option due to anticipated expiration of licensee authorization for such storage. In any such determination to proceed with centralized storage facility site selection, the Board shall consider, at a minimum, the following storage facility siting options and choose among those considered:
(a) Site a centralized short-term storage facility;
(b) Site a centralized long-term storage facility;
(c) Site a centralized interim or emergency storage facility.

<u>1.73 Treatment Facility</u>
(Reserved)

<u>1.74 Disposal facility</u>

(1) The Board hereby finds that there is a requirement for additional disposal facility capacity to meet present needs or needs anticipated to arise within the next decade.

(2) In any determination to proceed with disposal facility site selection pursuant to M.G.L. c.111H, s.17, the Board shall consider, at a minimum, the following disposal facility siting options and choose among those considered:
(a) Site a disposal facility for Massachusetts-only waste;
(b) Site a small regional disposal facility that would handle waste from Massachusetts and one or more neighboring states;
(c) Site a large regional disposal facility to accommodate waste from the New England states as well as other states searching for disposal options.

Facility Siting

<u>1.81 Requirements for Board Initiation of Siting</u>

(1) The Board shall initiate the site selection process established in M.G.L. c.111H, ss.18

through 23, inclusive, if it determines, by a two-thirds vote of its members, that it is necessary and appropriate to proceed with site selection. Such vote may be taken only if:

(a) the Board has adopted a Low-Level Radioactive Waste Management Plan incorporating a finding that there is a requirement for additional facility capacity to meet present needs or needs anticipated to arise within the next decade;

(b) DPH has adopted regulations, under M.G.L. c.111H, s.13, necessary to implement a program for source minimization, volume minimization, and storage for decay by generators;

(c) DEP has adopted regulations, under M.G.L. c.111H, s.14, establishing criteria for the selection of any superior site for the development and operation of a facility, guidelines for their application, and procedures for implementing the site selection process;

(d) the Board has adopted regulations, under M.G.L. c.111H, s.15, for the selection of operators; and

(e) DPH has adopted regulations, under M.G.L. c.111H, s.16, for the licensing, development, operation, closure, post-closure observation and maintenance and institutional control of a facility.

(2) No less than 21 days prior to a vote to initiate site selection pursuant to M.G.L. c.111H, s.17, the Board shall issue a notice, satisfying the requirements of M.G.L. c.30A, s.2, of its intent to conduct such vote.

(3) Upon the Board's vote to initiate site selection:

(a) The Board shall notify the Chief Executive Officer and Chief Elected Official of each community of the commencement of the site selection process, explaining in detail the site selection criteria, guidelines for their application and procedures for implementation of site selection, and offering the resources of the Board and the Public Participation Coordinator to assist communities in participating in the site selection process.

(b) The Board shall notify other states interested in negotiating the possibility of their generators' gaining access to a Massachusetts facility.

(c) The Board shall send press releases to pertinent newspapers, radio and television stations, and include an explanation of the public's role in waste management.

(d) The Public Participation Coordinator and other Board staff shall be available to attend meetings, conduct workshops, brief federal and state legislators and local officials, and generally to speak to interested groups about the siting process, to provide information, to answer questions, and to listen to concerns of the public.

(4) Upon voting to initiate site selection, the Board, with the assistance of the Public Participation Coordinator, shall prepare a siting plan, identifying the major decision points in the state's siting process, and summarizing the roles of responsible state agencies and potential site communities.

(5) The Board shall hire consultants, as necessary, to complete the site selection process.

1.82 Voluntary Siting Activities

(1) As part of the notification made pursuant to 345 CMR 1.81(3), the Board shall inform Chief Executive Officers and Chief Elected Officials of the opportunity to participate in voluntary siting activities.

(2) The Board shall give notice that grant funds will be available to communities that may be

interested in volunteering a site or sites, after the issuance of the Report Identifying Possible Locations pursuant to 345 CMR 1.84(1). The Board shall provide such grants to enable communities to evaluate the potential economic impacts of an LLRW facility.

1.83 Statewide Mapping and Screening

(1) The Board shall issue a Statewide Mapping and Screening Report prepared in accordance with any requirements of 310 CMR 41.44-41.45. Such Report shall identify, and exclude from further consideration in the site selection process, those areas of the commonwealth that are obviously unable to satisfy the site selection criteria set forth in 310 CMR 41.00.

(2) The Board shall conduct at least one public meeting on the Statewide Mapping and Screening Report at a time and location to be determined after consultation with the Public Participation Coordinator, and shall accept written comments thereon. The Board shall consider and evaluate all comments and statements made at a public meeting or submitted in writing.

1.84 Possible Locations

(1) After the issuance of the Statewide Mapping and Screening Report, the Board shall issue a Report Identifying Possible Locations, which are likely to contain one or more Candidate Sites that will satisfy the criteria set forth in 310 CMR 41.41(1)(a) and (b). The Report shall describe the procedures used to identify such Possible Locations and establish that such procedures conform to any requirements of 310 CMR 41.50-41.51.

(2) The Board shall provide a notice, satisfying the requirements of M.G.L. c.111H, s.19 to the Chief Executive Officer and Chief Elected Official of each community in which is located a Possible Location identified in the Report. All communities in which a Possible Location is located shall also receive a second notice of the opportunity to participate in voluntary siting activities, together with information about grant funds available pursuant to 345 CMR 1.82.

(3) The Board shall conduct at least one public meeting on the Report in the vicinity of each Possible Location identified in the Report at times and locations to be determined after consultation with the Public Participation Coordinator, and shall accept written comments thereon. The Board shall consider and evaluate all comments and statements made at a public meeting or submitted in writing.

1.85 Candidate Sites

(1) The Board shall issue a draft Candidate Site Identification Report. Such Report shall identify at least two, but not more than five candidate sites that appear to satisfy the requirements of 310 CMR 41.41(1), and that the Board considers to be potentially licensable, capable of being developed, and otherwise appropriate for detailed site characterization pursuant to M.G.L. c.111H, s.23. Such Report shall also include:
   (a) a report of the results of a preliminary characterization of the meteorology, surface and groundwater, geology, tectonics, geomechanics, air quality, ecology, land use, cultural resources and social and economic characteristics of each location considered as a possible candidate site;
   (b) a description of the procedures used to identify the candidate sites based on such preliminary characterization; and
   (c) draft plans for detailed site characterization of each candidate site.

(2) The preliminary characterization required pursuant to paragraph 1(a) of this section shall be conducted, to the extent feasible, so as not to interfere with the quiet enjoyment of private property; provided, however, that whenever the Board deems it necessary to make surveys, soundings, drillings or examinations to obtain information for, or to expedite the preliminary characterization, its authorized agents or employees may, after due notice by registered or certified mail, enter upon any lands, waters and premises, not including buildings, in the Commonwealth for the purposes of making surveys, soundings drillings and examinations as the Board may deem necessary or convenient, and such entry shall not be deemed a trespass. The Board shall make reimbursement for any injury or actual damage resulting to such lands, water and premises caused by any act of its authorized agents or employees, and the Board shall, so far as possible, restore such lands to the same condition as prior to the making of such surveys, soundings, drillings or examinations.

(3) Upon the issuance of the draft Candidate Site Identification Report, the Board shall transmit a copy of the draft Report to the Secretary of the Executive Office of Environmental Affairs; and widely publicize its availability for public review and comment; and the Board and the Commissioner of the Division of Capital Planning and Operation shall jointly provide a notice satisfying the requirements of M.G.L. c.111H, s.19 and M.G.L. c.7, s.40I to all persons entitled under section 40I to receive such notices and to the Chief Executive Officer and Chief Elected Official of each community in which is located all or part of a Candidate Site identified in such draft Report.

(4) No person owning property identified in the draft Candidate Site Identification Report shall take any action or cause to have any action taken with respect to such property prior to the acceptance or amendment of such Report by the Board which has the effect of interfering with or rendering more difficult or expensive the conduct of Detailed Site Characterization of the property or the acquisition of a property interest therein.

(5) The Board shall conduct at least one public meeting on the report in each community in which is located all or part of a Candidate Site identified in the draft Report, at times to be determined after consultation with the Public Participation Coordinator. Such public meeting shall be deemed to satisfy the public hearing requirements of M.G.L. c.7, s.40I. The Board shall accept written comments on the Report submitted within 60 days of the public notice of its availability. Prior to its acceptance of the draft Report, the Board shall consider and evaluate all comments and statements made at a public meeting or submitted in writing.

(6) Upon receipt of the draft Report, the Secretary shall implement the public review and comment procedures established pursuant to M.G.L. c.30, s.62C; provided, however, that the review period established in such section shall not extend beyond the final date for acceptance of written comments by the Board pursuant to paragraph 5 of this section. Within 60 days of the issuance of the draft Report, the Secretary shall issue a statement evaluating its technical adequacy and conformance with 310 CMR 41.00. The Secretary shall transmit a copy of such statement to the Board.

(7) The Board shall conduct a vote to determine whether to accept the Report and to proceed with detailed site characterization of the candidate sites identified therein, or amend the Report and proceed with detailed site characterization of the candidate sites identified in the Report as amended. Such a vote shall be based on the technical adequacy of the Report and its conformance with any requirements of 310 CMR 41.60 - 41.63. If the Board fails to accept or amend the Report, the Report shall be set aside and the procedures established in this section shall be repeated; provided, however, that the Board shall issue

its revised draft Report within four months of the expiration of the time for it to accept or amend the previous Candidate Site Identification Report.

1.86 Detailed Site Characterization

(1) Upon the Board's vote to proceed with Detailed Site Characterization, the Commissioner of the Division of Capital Planning and Operations shall, on behalf of the Board, take appropriate action to acquire, by purchase or taking, pursuant to M.G.L. c.79, a determinable property interest in each Candidate Site identified in the Candidate Site Identification Report as accepted or amended by the Board, or, in the case of real property of the Commonwealth, to transfer the control and use of such property to the Board. Acquisition or transfer of each such property interest shall be subject to the requirements of M.G.L. c.7, ss.40E-40M, inclusive; provided, however, that each Candidate Site shall be deemed to possess unique qualities for the purpose of M.G.L. c.7, s.40H. Such property interest shall be adequate to permit the conduct of Detailed Site Characterization of the property, in accordance with any requirements of 310 CMR 41.70-41.72, and to restrict the right to develop the property until a facility license is issued, pursuant to M.G.L. c.111H, s.31, to operate a facility at one of the Candidate Sites identified in the Candidate Site Identification Report as accepted or modified by the Board.

(2) The Board and the appropriate Community Supervisory Committee shall jointly conduct a public meeting in each Candidate Site Community to discuss the draft plan for the Detailed Site Characterization of the Candidate Site located within such community. Copies of the Report and draft plan shall be sent to all municipal libraries in such communities. The Detailed Site Characterization plan adopted by the Board shall include investigations and tests, both in the field and in the laboratory, which shall be conducted so as to demonstrate whether the site complies with the site selection criteria set forth in 310 CMR 41.00; to provide information necessary for licensing of any facility at the site pursuant to 105 CMR 120.800, including an evaluation of the ability of the site characteristics to contribute to isolation of waste, data necessary for the proposed design of such a facility, an identification of potential interactions between the site characteristics and any waste or waste containers located at the site to establish data collection points and baseline data suitable for use in an environmental monitoring program adopted pursuant to M.G.L. c.111H, s.36; and to identify, for inclusion in any environmental impact report prepared pursuant to M.G.L. c.111H, s.30, potential environmental impacts resulting from the development, operation, closure, postclosure observation and maintenance or institutional control of a facility at the site. Prior to its adoption of the final plan, the Board shall consider and evaluate all comments made at a public meeting or in writing.

(3) While Candidate Sites are undergoing Detailed Site Characterization, the Board shall develop estimates of the number of waste shipments necessary to each Candidate Site during a given time frame, and shall evaluate traffic controls that will minimize potential traffic problems.

(4) The Board shall issue a draft Report of the Detailed Site Characterization of each Candidate Site, and shall transmit a copy of such Report to the Secretary and the Community Supervisory Committee. The draft Report shall describe the procedures used to characterize each Candidate Site and establish that procedures fully conform to any requirements of 310 CMR 41.70-41.72.

(5) Upon issuance of the draft Detailed Site Characterization Report, the Board shall widely publicize its availability for public review and comment, and the Commissioner of the

Division of Capital Planning and Operations shall issue a notice, satisfying the requirements of M.G.L c.7, s.40I, to all persons entitled thereby to review such notice. The Board shall conduct at least one public meeting on the Report, in each Candidate Site Community, at times to be determined after consultation with the Public Participation Coordinator. Such public meeting shall be deemed to satisfy the public hearing requirements of section 40I. The Board shall accept written comments on the Report submitted by the Community Supervisory Committee or any other interested person within 60 days of the public notice of its availability.

(6) Upon receipt of the draft Detailed Site Characterization Report, the Secretary shall implement the public review and comment procedures established pursuant to M.G.L c.30, s.62C; provided, however, that the review period established in such section shall not extend beyond the final date for acceptance of written comments by the Board pursuant to this section. Within 75 days of the issuance of the Report, said Secretary shall issue a statement evaluating its technical adequacy and conformance with any requirements of 310 CMR 41.70-41.72. The Secretary shall transmit a copy of such statement to the Board and the Community Supervisory Committee.

(7) No sooner than 75 days and no later than 90 days after the issuance of the draft Detailed Site Characterization Report, the Board shall conduct a vote to determine whether to accept or amend the Report. Such a vote shall be based on the technical adequacy of the Report and its conformance with any requirements of 310 CMR 41.70-41.72. Prior to its acceptance of the Report, the Board shall consider and evaluate all comments made at a public meeting or submitted in writing. If the Board fails to accept or amend the Detailed Site Characterization Report, the Report shall be set aside, and the procedures established in this section shall be repeated; provided, however, that the Board shall meet with each Community Supervisory Committee to discuss the draft plan for implementing the revised Detailed Site Characterization within 30 days of the expiration of the time for the Board to accept or modify the Detailed Site Characterization Report; and provided, further, that the Board shall issue its revised Detailed Site Characterization Report within one year and two months of the expiration date of the time for the Board to accept or amend the prior Detailed Site Characterization Report.

1.87 Selection of Superior Site

(1) Upon voting to accept or modify a Detailed Site Characterization Report, the Board may select any Superior Site by a two-thirds vote of its members. Upon such vote, the Commissioner of the Division of Capital Planning and Operations shall, on behalf of the Board, take appropriate action to acquire, by purchase or taking, pursuant to M.G.L c.79, a fee simple interest in the Superior Site, together with such other land, easements, rights-of-way or other property interests necessary to construct and operate a facility thereon and to conduct an environmental monitoring program pursuant to M.G.L c.111H, s.36 or, in the case of real property of the Commonwealth, to transfer the control and use of such property to the Board. Such acquisition or transfer shall be subject to the requirements of M.G.L c.7, ss.40E - 40M, inclusive; provided, however, that the Superior Site shall be deemed to possess unique qualities for the purposes of M.G.L c.7, s.40H. Upon the acquisition of such interest, each site community, during the period prior to the issuance of a facility license, shall be entitled to receive an amount in lieu of local property taxes in accordance with M.G.L c.50, s.17. No facility developed at a Superior Site selected pursuant to this section shall be subject to site assignment pursuant to M.G.L c.111, s.150B.

(2) Upon the selection of a Superior Site, additional members shall be appointed to the Board as follows:

(a) The Chief Executive Officer of each site community in which is located a facility that is in development, operation, closure, post-closure observation and maintenance or institutional control pursuant to M.G.L. c.111H, shall appoint a community resident to serve as a member of the Board.

(b) If there is only one site community in the Commonwealth, the Chief Executive Officer of the neighboring community having the greatest population residing within three miles of the Superior Site, shall also appoint a community resident to serve as a member of the Board, but, if no community is eligible for such appointment, the Chief Executive Officer of the site community shall appoint a second site community resident to serve as a member of the Board.

(3) Within 60 days of the selection of any Superior Site or, if a petition for an adjudicatory proceeding has been filed pursuant to M.G.L. c.111H, s.24, within 30 days of a final decision of the Commissioner of DEP approving the site selection, the Board shall establish a field office within a site community outside the boundaries of the Superior Site.

(4) Any person aggrieved by an action taken pursuant to M.G.L. c.111H, s.19, 20 or 23 may petition the Commissioner of DEP, in accordance with M.G.L. c.111H, s.24, for an adjudicatory proceeding.

1.88 Community Supervisory Committee Requirements

(1) The Board shall designate a committee to assume the responsibilities of the Community Supervisory Committee for each Candidate Site Community if the Chief Executive Officer of such community fails to take appropriate action to establish the Community Supervisory Committee within 45 days of the issuance of the draft Candidate Site Identification Report. The committee so designated shall assume such responsibilities until the Community Supervisory Committee is established.

(2) The Board shall provide technical assistance to each Community Supervisory Committee and sufficient funds to enable it to acquire administrative and clerical personnel and to retain consultants necessary to exercise its powers and duties. The Board shall inform Community Supervisory Committees about policies relating to compensation and benefits available to their communities, and about the availability of state resources for local economic assistance.

(3) Each Community Supervisory Committee shall assist the Board in developing a Detailed Site Characterization plan for a Candidate Site located within the community and participate throughout the implementation of such Detailed Site Characterization plan. Appropriate Board officials and consultants shall meet monthly with each Community Supervisory Committee.

(4) The Board shall keep each Community Supervisory Committee informed of the progress of the Detailed Site Characterization; furnish the Community Supervisory Committee with copies of all data, reports, and memoranda pertaining to the Detailed Site Characterization including raw data, draft reports and memoranda; and give the Community Supervisory Committee reasonable opportunity to review and comment upon all work performed.

(5) Upon the expiration of 30 days after the selection of any Superior Site or, if a petition for an adjudicatory proceeding has been filed pursuant to M.G.L. c.111H, s.24, upon a final

decision of the Commissioner of the DEP approving the site selection, the Board shall request the Chief Executive Officer of each neighboring community to appoint a representative to the Community Supervisory Committee of each site community. If the Chief Executive Officer of a neighboring community fails to take such action within 21 days of receiving such request, the Board shall make the appointment.

1.89 Property Value Guarantee

(1) Any person owning real property, any portion of which is located within the property value protection district identified by the Board, after consultation with the community supervisory committee, shall be entitled to a guarantee of the value of such property in accordance with the provisions of this section. Such guarantee shall be effective upon the Board's selection of a Superior Site for a facility pursuant to M.G.L. c.111H, s.23(g).

(2) A seller seeking compensation for lost value of real property pursuant to this section shall submit a request for compensation to the Board, together with:

(a) a copy of a purchase and sale agreement for such property executed after the date of the Board's adoption of a Candidate Sites Identification Report, in which the site is identified as a Candidate Site, and containing a provision making the agreement subject to a right of first refusal satisfying the requirements of 345 CMR 1.89(2)(b), if applicable;

(b) In the case of a purchase and sale agreement executed after the selection of a Superior Site pursuant to M.G.L. c.111H, s.23(g), an agreement, executed by the parties to the agreement granting the Commonwealth a right of first refusal to purchase the property in accordance with the terms and conditions of the agreement;

(c) an appraisal, made by a person qualified to make such an appraisal, of the actual value of the property as of the date of execution of the purchase and sale agreement;

(d) an appraisal, made by a person qualified to make such an appraisal, of the value the property would have, as of the date of execution of the purchase and sale agreement, but for the facility or the possibility of the facility.

(3) The facility operator shall pay to a seller of real property who seeks compensation in accordance with this section an amount equal to the difference in the value such property would have, as of the execution of the purchase and sale agreement submitted to the Board, but for the facility or the possibility of the facility, and any lesser actual value of such property as of the date of execution of the purchase and sale agreement. Such amount shall be determined by the Board, after notice to the facility operator, and an opportunity for the facility operator to review and comment upon the request and accompanying documentation. In making its determination, the Board may consider the actual purchase price paid for the property, and any appraisals it may obtain or be provided in addition to those submitted by the seller.

(4) No payment shall be required pursuant to this section:

(a) unless the property is located within the property value protection district for a licensed facility;

(b) prior to facility licensing pursuant to M.G.L. c.111H, s.39;

(c) until the seller provides the Board with a copy of the deed conveying title to such property to the Commonwealth or in accordance with the purchase and sale agreement, together with evidence that such deed has been recorded at the appropriate Registry of Deeds;

(d) if a facility operator has previously made a payment pursuant to this section with respect to the property; or

(e) unless the property is conveyed no later than five years after facility licensing.

(5) Any person aggrieved by a decision of the Board made pursuant to this section may request an adjudicatory hearing thereon. Such adjudicatory proceeding shall be conducted in accordance with the standard Adjudicatory Rules of Practice and Procedure, Formal Rules, 801 CMR 1.01.

Facility Insurance Requirements

1.91 Insurance Plans Required.

(1) A disposal facility operator shall purchase and maintain the following insurance plans at all times during facility operation, closure and post-closure observation and maintenance:

(a) All-Risk Property Insurance, to insure the facility itself (including costs of replacement of the buildings and equipment) in an amount equal to the facility's replacement cost, or the maximum amount available, whichever is less.

(b) Comprehensive General Liability Insurance, with minimum limits of $25 million per occurrence and $25 million in the aggregate.

(c) Environmental Impairment Liability Insurance, with minimum limits of $10 million, or such greater amounts, up to the maximum loss potential determined by a financial risk assessment acceptable to the Board, as may from time to time be commercially available.

(d) Nuclear Energy Liability Insurance, with minimum limits equal to $25 million or the maximum loss potential determined by a risk assessment acceptable to the Board. The facility operator shall use its reasonable best efforts to obtain such insurance at the required amount. Since such insurance is not currently available in amounts sufficient to satisfy the requirements of this paragraph, the facility operator shall, through a letter of credit or other acceptable means, establish an escrow arrangement equal to the difference between the available nuclear energy liability insurance policy limits and the required insurance amount.

(2) Any decision to site a treatment or storage facility pursuant to M.G.L. c.111H shall be followed by a financial risk assessment of such facility. The same types of insurance plans specified in 345 CMR 1.91(1) shall be required, but maximum limits will be determined after consideration of the specific storage and treatment activities anticipated.

1.92 Adequacy of Insurance Program. An insurance program conforming to the requirements of 345 CMR 1.91 may be deemed adequate by the Board for a disposal facility only if appropriate bond arrangements, acceptable to the Board, are made for on-site remedial action in amounts equal to the maximum loss potential determined by a financial risk assessment acceptable to the Board.

Appendix F: Summary of 1992 Inventory of Massachusetts Low-Level Radioactive Waste Generators

The Low-Level Radioactive Waste Management Act, Massachusetts General Laws c.111H, requires this Management Plan to include an inventory of information about all Massachusetts generators of low-level radioactive waste (LLRW).

Data on management practices, including the minimization of radioactive sources and LLRW volumes; storage, treatment, and disposal activities; waste packaging; transportation; and other LLRW management issues, are contained in various chapters of VOLUME II. Appendix F presents information on each 1992 generator's location; use of radioactive materials; total volume produced as a result of those uses; treatment practices employed; waste volume and activity shipped to licensed disposal facilities; types of disposal packages used; and number of shipments.

The number of radioactive materials users in Massachusetts that generate LLRW varies from year to year. Except in the case of decommissioning activities and routine refueling events of the nuclear-powered utilities -- which generate higher-than-average LLRW volumes -- the production of LLRW by Massachusetts radioactive materials users is relatively predictable. As a result of data collected through the annual survey of all radioactive materials users, the Low-Level Radioactive Waste Management Board estimates that the annual volume of LLRW requiring disposal off site will be 20,000-25,000 cubic feet. An additional 450,000 cubic feet from future decommissioning activities is also expected to require disposal in a licensed disposal facility.

Detailed information from the annual survey of radioactive materials users is published by the Management Board in a yearly report, and is available by contacting the Board's office at 100 Cambridge Street, Room 903, Boston, Massachusetts 02202 [telephone (617) 727-6018].

1992 Inventory of LLRW Generators

City	Organization	Reason for Use of Radioactive Materials	Volume Produced (cubic feet)	Reported Treatment Code[1,2]	Volume Shipped (cubic feet)	Activity Shipped (curies)	Shipping Containers	Number of Shipments	Volume Stored On-Site
Barnstable County									
Falmouth	Falmouth Hospital	Diagnostic nuclear medicine	100.0		0.0	0.0000		0	0.0
Hyannis	Cape Cod Hospital	Diagnostic nuclear medicine	150.0		0.0	0.0000		0	0.0
Hyannis	Cardiac Imaging, Inc.	Nuclear diagnostic imaging	10.0		0.0	0.0000		0	0.0

1992 Inventory of LLRW Generators (continued)

City	Organization	Reason for Use of Radioactive Materials	Volume Produced (cubic feet)	Reported Treatment Code[1,2]	Volume Shipped (cubic feet)	Activity Shipped (curies)	Shipping Containers	Number of Shipments	Volume Stored On-Site
Woods Hole	Marine Biological Laboratory	Biomedical research and education	125.4	4, 10	60.3	0.0520	55 Gal. Drum	2	0.0
Woods Hole	Woods Hole Ocean-ographic Institute	Research	70.1	10	16.0	0.0003	30 Gal. Drum	[illegible]	0.0
Berkshire County									
Great Barrington	Fairview Hospital	Nuclear medicine	9.0		0.0	0.0000		2	0.0
North Adams	North Adams Regional Hospital	Diagnostic nuclear medicine	11.0		0.0	0.0000		0	0.0
North Adams	Sprague Electric Co.	Decommissioning waste awaiting shipment	22.0		22.0	0.0045	80 Gal. Drum	1	16,685.0
Pittsfield	Berkshire Medical Center	Medical use	500.0		0.0	0.0000		0	0.0
Pittsfield	Hillcrest Hospital	Diagnostic nuclear medicine	10.0		0.0	0.0000		0	0.0
Williamstown	Williams College	Teaching and research	15.0		0.0	0.0000		0	4.0
Bristol County									
Attleboro	Sturdy Memorial Hospital	Diagnostic nuclear medicine	7.5		0.0	0.0000		0	0.0
Attleboro	Texas Instruments	Remediation of soils at a former LLRW burial site	54,719.0		54,719.0	0.7650	Rail Car	48	0.0
Fall River	Charlton Memorial Hospital	Diagnostic nuclear medicine	100.0		0.0	0.0000		0	0.0
Mansfield	Clinical Science Laboratory, Inc.	In-vitro testing	175.0		0.0	0.0000		0	0.0
New Bedford	Prym/Dritz Corporation	Static electricity eliminators	7.5		7.5	0.1900		1	0.0
New Bedford	St Luke's Hospital	Diagnostic nuclear medicine	125.0		0.0	0.0000		0	0.0

1992 Inventory of LLRW Generators (continued)

City	Organization	Reason for Use of Radioactive Materials	Volume Produced (cubic feet)	Reported Treatment Code[1,2]	Volume Shipped (cubic feet)	Activity Shipped (curies)	Shipping Containers	Number of Shipments	Volume Stored On-Site
North Attleboro	Mallinckrodt Medical, Inc.	Manufacture/distribution of pharmaceuticals	910.0	1, 14	8.0	0.0000	30 Gal. Drum	14	2.0
North Dartmouth	Massachusetts, University of	Research & teaching	4.0		0.0	0.0000		0	0.0
Taunton	Morton Hospital and Medical Center	Diagnostic nuclear medicine	50.0		0.0	0.0000		0	0.0
Dukes County									
Oak Bluffs	Martha's Vineyard Hospital	Diagnostic nuclear medicine	7.5		0.0	0.0000		0	0.0
Essex County									
Amesbury	Amesbury Hospital	Diagnostic imaging	6.0		0.0	0.0000		0	0.0
Andover	Elsai Research Institute	R & D using biological assays	100.0	1, 10	3.0	0.0150	55 Gal. Drum	2	0.0
Andover	Raytheon Company	Testing of semi-conductor components	1.0		0.0	0.0000		0	0.0
Beverly	Autogen Instrumentation, Inc.	Research & development	7.5		0.0	0.0000		0	0.0
Beverly	Beverly Hospital	Diagnostic nuclear medicine	4.0		0.0	0.0000		0	0.0
Beverly	New England Biolabs, Inc.	BiotechnologyR & D	72.5		0.0	0.0000		0	0.0
Beverly	Varian Associates	Manufacture of electron devices	75.0		75.0	59.5658	55 Gal. Drum	3	15.0
Danvers	Diagnostic Management Services, Inc.	Diagnostic nuclear medicine	7.5		0.0	0.0000		0	0.0
Danvers	W R Grace & Co., Amicon Div.	Measurement of product separation properties	37.5	1, 10	1.5	0.0050	Vendor Choice	1	0.0

1992 Inventory of LLRW Generators (continued)

City	Organization	Reason for Use of Radioactive Materials	Volume Produced (cubic feet)	Reported Treatment Code[1,2]	Volume Shipped (cubic feet)	Activity Shipped (curies)	Shipping Containers	Number of Shipments	Volume Stored On-Site
Gloucester	Addison Gilbert Hospital	Diagnostic nuclear medicine	5.0		0.0	0.0000		0	0.0
Haverhill	Hale Hospital	Clinical nuclear medicine	6.0		0.0	0.0000		0	0.0
Lawrence	Lawrence General Hospital	Diagnostic nuclear medicine	16.0		0.0	0.0000		0	0.0
Lawrence	MassachusettsDept. of Environmental Protection	Gas chromatography	0.0		0.0	0.0300		1	0.0
Lynn	AtlantiCare Medical Center	Diagnostic nuclear medicine	106.6		6.6	0.2450	55 Gal. Drum	1	0.0
Lynn	General Electric Co.	Chemical analysis of samples	5.1		5.1	0.0006	30, 55 Gal. Drum	1	0.0
Methuen	Holy Family Hospital and Medical Center	Diagnostic and therapeutic treatment of patients	164.0		0.0	0.0000		0	0.0
Newburyport	Anna Jacques Hospital	Nuclear Medicine	20.0		0.0	0.0000		0	0.0
North Andover	AT&T Network Systems	Leak testing, measurement of thickness and density	2,600.0		0.0	0.0000		0	0.0
North Andover	Mediq Imaging Services, Inc.	Nuclear medicine diagnostic imaging	90.0		0.0	0.0000		0	0.0
North Andover	RTS Technology Inc.	Manufacture of sealed sources	15.0		0.0	0.0000		0	0.0
Peabody	J B. Thomas Hospital	Diagnostic nuclear medicine	9.5		0.0	0.0000		0	0.0
Salem	EG&G, Inc.	Development, manufacture, testing, distribution of electron tubes	11.3	4	2.0	0.0200	55 Gal. Drum	1	3.8
Salem	New England Power Co.	Measurement of coal fly-ash level	5.5	11	1.1	0.0080	Broker Choice	1	0.0

1992 Inventory of LLRW Generators (continued)

City	Organization	Reason for Use of Radioactive Materials	Volume Produced (cubic feet)	Reported Treatment Code[1,2]	Volume Shipped (cubic feet)	Activity Shipped (curies)	Shipping Containers	Number of Shipments	Volume Stored On-Site
Salem	Salem Hospital	Nuclear medicine	15.0		0.0	0.0000		0	0.0
Franklin County									
Greenfield	Franklin Medical Center	Diagnostic nuclear medicine	4.5		0.0	0.0000		0	0.0
Rowe	Yankee Atomic Electric Company	Decommissioning of a nuclear power plant, laboratory services	7,237.5		7,237.5	32,144.7017	30, 55 Gal. Drum; Steel Liner; Metal, Wood Box; Poly Hic	17	0.0
Hampden County									
Chicopee	Our Lady of the Elms College	Training and teaching	2.0		0.0	0.0000		0	2.0
Chicopee	Westover AFB	Compasses using sealed tritium sources	7.0		7.0	10.4800		1	0.0
Holyoke	Holyoke Hospital	Diagnostic nuclear medicine	92.0		0.0	0.0000		0	0.0
Ludlow	Ludlow Hospital	Diagnostic nuclear medicine	5.0		0.0	0.0000		0	0.0
Springfield	Baystate Medical Center	Diagnostic nuclear medicine, radiation therapy, radioimmunoassay	102.0		0.0	0.0000		0	0.0
Springfield	Cameo Diagnostic Center, Inc.	Diagnostic nuclear medicine	7.5		0.0	0.0000		0	0.0
Springfield	Interstate Nuclear Services	Laundering of protective clothing	126,377.9	4	397.5	0.5945	Vendor choice	1	282.3
Westfield	Noble Hospital	Nuclear medicine imaging	10.0		0.0	0.0000		0	0.0

1992 Inventory of LLRW Generators (continued)

City	Organization	Reason for Use of Radioactive Materials	Volume Produced (cubic feet)	Reported Treatment Code[1,2]	Volume Shipped (cubic feet)	Activity Shipped (curies)	Shipping Containers	Number of Shipments	Volume Stored On-Site
Hampshire County									
Amherst	Amherst College	Scientific research and teaching	4.0		0.0	0.0000		0	0.0
Amherst	Massachusetts, University of	Life and physical research and teaching	345.0		0.0	0.0000		0	15.0
Northampton	Smith College	Research and teaching	42.0	10, 12, 14	18.8	0.0265	55 Gal. Drum	2	0.0
Northampton	VA Hospital Northampton	Diagnostic nuclear medicine	5.0		0.0	0.0000		0	0.0
South Hadley	Mount Holyoke College	Laboratory research	15.0		0.0	0.0000		0	0.0
Middlesex County									
Arlington	Symmes Hospital	Clinical nuclear medicine	5.0		0.0	0.0000		0	0.0
Ayer	Nashoba Community Hospital	Diagnostic nuclear medicine	12.0		0.0	0.0000		0	0.0
Bedford	CIS-US, Inc.	Manufacture and distribution of radiopharmaceuticals	31.0	1	6.2	0.0859		1	11.3
Bedford	ENRM VA Hospital	Medical research	116.5	2, 10	26.5	0.0145	55 Gal. Drum	6	0.0
Bedford	Millipore Corporation	Analytical research	24.7		0.0	0.0000		0	40.5
Billerica	Du Pont Merck Pharmaceutical Co.	Manufacture of radiopharmaceuticals	10,802.2	4	748.6	67.6224	55, 85 Gal. Drum	8	166.0
Billerica	E. I. Du Pont De Nemours and Co.	Manufacture of radiopharmaceuticals	3,002.8	4	823.8	66.6863	55, 85 Gal. Drum	8	307.5
Billerica	E. I. Du Pont De Nemours and Co.	Manufacture of radiopharmaceuticals	1,078.5	4	996.9	0.8079	55 Gal. Drum; B87-6 Cask	3	843.0
Burlington	Amersham Corporation	Manufacture of sealed sources	258.0		30.0	0.2710	55 Gal. Drum	1	279.5

1992 Inventory of LLRW Generators (continued)

City	Organization	Reason for Use of Radioactive Materials	Volume Produced (cubic feet)	Reported Treatment Code[1,2]	Volume Shipped (cubic feet)	Activity Shipped (curies)	Shipping Containers	Number of Shipments	Volume Stored On-Site
Burlington	Lahey Clinic Medical Center	Diagnostic nuclear medicine	77.6		0.0	0.0000		0	0.0
Burlington	Millipore Corporation	Life science R & D	19.0	10	15.0	0.0310	55 Gal. Drum	0	0.0
Burlington	M/A-COM, Inc.	Manufacture of microwave receiver protector tubes	24.1	1	24.1	9.1157	30 Gal. Drum; Steel Box	4	0.0
Cambridge	Advanced Magnetics, Inc.	Manufacture of diagnostic and research reagents	269.4	10, 18	38.9	0.0189	30, 55 Gal. Drum	10	5.0
Cambridge	American Science & Engineering, Inc.	Instrument calibration	4.0		4.0	0.3427	30 Gal. Drum	0	0.0
Cambridge	Applied bioTechnology, Inc.	Molecular biology & protein chemistry	30.0	1	22.5	0.0370	55 Gal. Drum	2	0.0
Cambridge	Ariad Pharmaceuticals, Inc.	BiotechnologyR & D	7.4		0.0	0.0000		0	2.7
Cambridge	Arthur D. Little, Inc.	Biochemical experimentation	15.0		15.0	0.0050	Vendor choice	1	0.0
Cambridge	BASF Bioresearch Corp.	BiotechnologyR & D	180.5	10	165.5	0.1854	55 Gal. Drum	5	0.0
Cambridge	Biogen, Inc.	BiotechnologyR & D	271.8	10	30.0	0.0615		2	0.0
Cambridge	Bioran Medical Laboratory	Medical laboratory testing	0.9		0.0	0.0000		0	0.0
Cambridge	BioSurface Technology, Inc.	Radiolabeling of materials	41.0		0.0	0.0000		0	16.0
Cambridge	Boston Heart Foundation	Biochemical/ biologicaL research	3.0		0.0	0.0000		0	0.0
Cambridge	Cambridge Neuro-science Research	Bio-research	542.8	3, 10	89.8	0.1850	30, 55 Gal. Drum	12	27.6
Cambridge	Charles Stark Draper Lab, Inc.	Radiation hardness testing of electronic and mechanical components	4.0		0.0	0.0000		0	0.0

1992 Inventory of LLRW Generators (continued)

City	Organization	Reason for Use of Radioactive Materials	Volume Produced (cubic feet)	Reported Treatment Code[1,2]	Volume Shipped (cubic feet)	Activity Shipped (curies)	Shipping Containers	Number of Shipments	Volume Stored On-Site
Cambridge	CytoMed, Inc.	Bioassay tracers, molecular biological probes, radioimmunoassay	96.3	1, 10	5.0	0.0029	55 Gal. Drum	2	15.0
Cambridge	Enzytech, Inc.	Radioimmunoassay	42.5	10	30.0	0.0140	55 Gal. Drum	2	12.0
Cambridge	Genetics Institute	Research & development	480.0	1, 10	300.0	1.0273	55 Gal. Drum	15	52.5
Cambridge	Genzyme Corp.	Molecular biology, DNA probe testing, enzyme assay	1,123.1		52.5	0.0401	55 Gal. Drum	3	9.0
Cambridge	ImmuLogic Pharmaceutical Corp.	Biomedical research	467.0	10	52.5	0.0224	55 Gal. Drum	7	0.0
Cambridge	ImmunoGen, Inc.	Biochemical & biological research	88.5	10	4.5	0.0055	30 Gal. Drum	2	15.0
Cambridge	International Bio-technology Labs, Inc.	R & D biotechnological products	9.2	1	2.5	0.0003	55 Gal. Drum	0	0.1
Cambridge	Massachusetts Institute of Technology	Research and teaching	1,753.6	10	420.0	1.7288	55 Gal. Drum	9	0.0
Cambridge	Matritech, Inc.	R & D of cancer diagnostic assays	62.0		0.0	0.0000		0	0.0
Cambridge	Metpath, Inc.	Clinical diagnostic testing	107.3		106.0	0.0026	30, 55 Gal. Drum	11	0.0
Cambridge	Mt. Auburn Hospital	Diagnostic nuclear medicine	95.3		0.0	0.0000		0	0.0
Cambridge	OmniGene, Inc.	Biochemical research	137.5		0.0	0.0000		0	7.5
Cambridge	Oravax, Inc	Biomedical research	4.0		0.0	0.0000		0	0.0
Cambridge	Organogenesis, Inc.	R & D of medical devices	124.0	1, 10	94.0	0.0046	55 Gal. Drum	3	0.0
Cambridge	Osteo Arthritis Sciences	Biotechnology R & D	24.5		0.0	0.0000		0	22.5

1992 Inventory of LLRW Generators (continued)

City	Organization	Reason for Use of Radioactive Materials	Volume Produced (cubic feet)	Reported Treatment Code[1,2]	Volume Shipped (cubic feet)	Activity Shipped (curies)	Shipping Containers	Number of Shipments	Volume Stored On-Site
Cambridge	Peptimed, Inc	Laboratory activities in biotechnology	5.0		0.0	0.0000		0	0.0
Cambridge	PharmaMar USA, Inc.	In-vitro biological experiments	7.5		0.0	0.0000		0	7.5
Cambridge	Procept, Inc.	BiotechnologyR & D	120.5	1, 10	9.4	0.0644	Vendor Choice	6	0.0
Cambridge	Protein Engineering Corp.	R & D of therapeutic and diagnostic products	13.0		0.0	0.0000		0	2.7
Cambridge	Shared Diagnostic Services	Diagnostic nuclear medicine	7.5		0.0	0.0000		0	0.0
Cambridge	T Cell Sciences, Inc.	R & D of pharmaceuticals	142.7	1, 10	8.2	0.0333	Vendor choice	4	9.4
Cambridge	Therion Biologics Corporation	Molecular biological and protein chemistry	4.1		0.0	0.0000		0	0.0
Cambridge	Transkaryotic Therapies, Inc.	Molecular biological probes, radioimmunoassay	75.0		45.0	0.0001	55 Gal. Drum	2	0.0
Cambridge	TRW Fasteners Division	No longer use RAM	1.0		0.0	0.0000		0	0.0
Cambridge	Vertex Pharmaceuticals	R & D of human pharmaceuticals	130.0	1, 10	22.5	0.0020	55 Gal. Drum	1	0.0
Cambridge	Whitehead Institute for Biomedical Research	Biomedical, Cancer, and Aids research	849.2	1, 10, 14	150.0	0.6903	55 Gal. Drum	5	0.0
Cambridge	Alkermes, Inc.	Pharmaceutical R & D	393.6	10	45.5	0.0103	30, 55 Gal. Drum	9	0.0
Chestnut Hill	Boston College	Research and teaching	479.3	1	118.3	0.0259	46 cu ft box; 30 Gal. Drum	4	0.0
Concord	Emerson Hospital	Diagnostic nuclear medicine	100.0		0.0	0.0000		0	0.0

1992 Inventory of LLRW Generators (continued)

City	Organization	Reason for Use of Radioactive Materials	Volume Produced (cubic feet)	Reported Treatment Code[1,2]	Volume Shipped (cubic feet)	Activity Shipped (curies)	Shipping Containers	Number of Shipments	Volume Stored On-Site
Concord	Nuclear Metals, Inc.	Manufacture of depleted uranium products and components	12,327.3	4, 10	6,470.6	4.4029	55, 89 Gal. Drum; B-25 Box; Poly Bag; Steel Box	14	0.0
Concord	Oxford Analytical, Inc.	Service of XRF analyzers	0.5		0.5	0.6300	55 Gal. Drum	1	0.0
Everett	Whidden Memorial Hospital	Diagnostic nuclear medicine	43.0		0.0	0.0000		0	0.0
Framingham	Betagen Corporation	R & D of laboratory instrumentation	7.4		0.0	0.0000		0	0.8
Framingham	Gene-Trak Systems	DNA/RNA Research	847.5	1, 10	7.5	0.0202	55 Gal. Drum	2	90.0
Hopkinton	Biomeasure, Inc.	Research in life sciences	195.0		0.0	0.0000		0	0.0
Hopkinton	Creative Biomolecules, Inc.	Animal studies	105.0	10	90.0	0.0991	55 Gal. Drum	4	0.0
Hopkinton	Liberty Mutual Insurance Co.	Gas chromatography	4.0	4	4.0	0.2612		1	0.0
Hopkinton	Seragen, Inc.	Biomedical R & D	473.5	1, 10	342.0	0.1245	30, 55 Gal. Drum	12	0.0
Lexington	Environmental Protection Agency	Gas chromatography	0.5		0.0	0.0000		0	0.0
Lexington	Intemeuron Pharmaceuticals Inc.	Biochemical Assays	11.5	10	0.0	0.0000		0	0.0
Lexington	Repligen Sandoz Research Corp.	Protein labeling	11.5	10	4.0	0.0009	30 Gal. Drum	2	0.0
Lexington	W R Grace & Co.	RIA Assays	23.0		0.0	0.0000		0	0.0
Lowell	Lowell General Hospital	Diagnostic nuclear medicine	6.0		0.0	0.0000		0	0.0
Lowell	Lowell, University of Massachusetts	Research and training	48.1		0.0	0.0000		0	8.0

1992 Inventory of LLRW Generators (continued)

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Lowell	St John's Hospital	Diagnostic nuclear medicine	100.0		0.0	0.0000		0	0.0
Lowell	St Joseph's Hospital	Diagnostic nuclear medicine	100.0		0.0	0.0000		0	0.0
Malden	Charm Sciences, Inc.	Manufacture of In-vitro diagnostic kits	0.5		0.0	0.0000		0	0.5
Malden	Enzyme Center	Manufacture of in- vitro diagnostic kits	45.0		0.0	0.0000		0	0.0
Marlborough	Optical Corporation of America	Manufacture of gunsights	8.3		1.0	0.0031		1	7.8
Marlborough	Marlborough Hospital	Clinical nuclear medicine	5.0		0.0	0.0000		0	0.0
Medford	Lawrence Memorial Hospital of Medford	Diagnostic nuclear medicine	10.0		0.0	0.0000		0	0.0
Medford	Tufts University	Radiolabeling in bio-chemical\chemical experiments	152.0	10	0.0	0.0000		0	7.5
Melrose	Melrose/Wakefield Hospital	Medical diagnostic imaging	100.0		0.0	0.0000		0	0.0
Natick	Army, Department of	R & D as defined in Title 10 CFR 30.4	29.4		0.0	0.0000		0	30.9
Natick	Imaging Associates, Inc.	Diagnostic nuclear medicine	2.0		0.0	0.0000		0	0.0
Needham Heights	GTE Government Systems Corp.	Semiconductor R & D	0.5		0.0	0.0000		0	0.0
Newton	Cellcor Therapies, Inc.	Medical research and cancer treatment assessment	13.3		8.0	0.0001	30 Gal. Drum	2	0.0
Newton	Hygeia Sciences	QC & testing of uptake filters	8.5		0.0	0.0000		0	0.0

1992 Inventory of LLRW Generators (continued)

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Newton	Newton-Wellesley Hospital	Nuclear medicine program	7.5		0.0	0.0000		0	0.0
Somerville	Somerville Hospital	Nuclear medicine studies	7.5		0.0	0.0000		0	0.0
Somerville	Vicam	R&D for food analysis test kits	2.0		0.0	0.0000		0	4.0
Stoneham	New England Memorial Hospital	Diagnostic nuclear medicine	7.5		0.0	0.0000		0	0.0
Sudbury	Raytheon Company	Electronics R & D	0.5		0.0	0.0000		0	1.0
Waltham	Brandeis University	Basic research in Physics, Biology, Biochemistry, and Chemistry	331.6	4, 10	84.1	4.7950	4,55,85 Gal. Drum	8	0.0
Waltham	Digital Scintigraphics	Nuclear Medicine	20.0		0.0	0.0000		0	0.0
Waltham	Eunice Kennedy Shriver Center	Biomedical research and clinical assays	27.8		1.5	0.0002	55 Gal. Drum	2	0.0
Waltham	Panametrics, Inc.	R&D on radioisotope uses and instrumentation	13.9	13	9.8	0.0490		3	0.0
Waltham	Polaroid Corporation	Measurement of thickness and density	1.0		0.0	0.0000		0	0.0
Waltham	Raytheon Company	Manufacture of electron tube cathodes	515.0		500.0	0.0010	Steel Box	1	15.0
Waltham	Skinner & Sherman Laboratories	Analysis of soil samples	2.0		0.0	0.0000		0	6.0
Waltham	SmithKline Beecham Clinical Laboratory	Invitro diagnostic testing	232.7		232.7	0.0300	55 Gal. Drum	3	0.0
Watertown	Army, Department of	Decommissioning of Watertown Arsenal	32,291.2	9	32,291.2	76.1526		79	0.0
Watertown	Radiation Monitoring Devices, Inc.	Calibration of radiation detectors	0.0		0.0	0.0000		0	0.0

City	Organization	Reason for Use of Radioactive Materials	Volume Produced (cubic feet)	Reported Treatment Code[1,2]	Volume Shipped (cubic feet)	Activity Shipped (curies)	Shipping Containers	Number of Shipments	Volume Stored On-Site
1992 Inventory of LLRW Generators (continued)									
Wilmington	Charles River Labs., Inc.	Molecular DNA analysis	10.0		0.0	0.0000		0	0.0
Wilmington	New England Pathology Services	In-vitro biomedical testing	210.0		0.0	0.0006		0	0.0
Winchester	Winchester Hospital	Diagnostic nuclear medicine	7.5		3.1	0.0000		2	0.0
Winchester	Health & Human Services, Department of	Research and development	30.6		19.1	0.1358	30, 55 Gal. Drum	[illegible]	0.0
Winthrop	Winthrop Hospital	Diagnostic nuclear medicine	5.0		0.0	0.0000		0	0.0
Woburn	Biotechnology Management Association	Product testing of biotech and pharmaceutical products	10.0		0.0	0.0000		0	0.0
Woburn	BIOTEK, Inc.	R & D on medical products	22.5	10	7.5	0.0220	55 Gal. Drum	3	0.0
Woburn	Crystal Diagnostics, Inc.	R & D of gas measuring devices	12.2	1, 10	3.1	0.0015	Vendor Choice	2	0.0
Woburn	Micro-Dynamics, Inc.	Manufacture of microwave radar components	20.1		16.0	0.0006	30 Gal. Drum	1	4.0
Woburn	Syncor International Corp.	Compounding and distribution of radiopharmaceuticals	230.0		0.0	0.0000		0	0.0
Norfolk County									
Braintree	Clean Harbors Analytical Services, Inc.	Gas chromatography	15.0	10	0.0	0.0000		0	0.0
Medfield	Ciba Corning Diagnostics Corp.	No use of radioactive materials	7.5		0.0	0.0000		0	0.0

1992 Inventory of LLRW Generators (continued)

City	Organization	Reason for Use of Radioactive Materials	Volume Produced (cubic feet)	Reported Treatment Code[1,2]	Volume Shipped (cubic feet)	Activity Shipped (curies)	Shipping Containers	Number of Shipments	Volume Stored On-Site
Medfield	Strichman Medical Equipment	Diagnostic nuclear medicine	4.0		0.0	0.0000		0	0.0
Milton	Milton Hospital	Diagnostic nuclear medicine	7.5		0.0	0.0000		0	0.0
Needham	Glover Memorial Hospital	Diagnostic nuclear medicine	3.0		0.0	0.0000		0	0.0
Needham	Repligen Corporation	Biotech research	161.5	3, 10	22.3	0.1479	30, 55, 79 Gal. Drum	4	22.5
Norfolk	Southwood Community Hospital	Diagnostic and therapeutic purposes	27.0		0.0	0.0000		0	0.0
Norwood	Norwood Hospital	Diagnostic therapy	100.0		0.0	0.0000		0	0.0
Quincy	Procter & Gamble Mfg. Co.	Mass flow and liquid level measurements	1.0		0.0	0.0000		0	0.0
Quincy	Quincy City Hospital	Diagnostic nuclear medicine	100.0		0.0	0.0000		0	0.0
Randolph	Ares Advanced Technology, Inc.	R & D of Pharmaceuticals	169.0		0.0	0.0000		0	0.0
Randolph	Serono Laboratories, Inc.	Manufacture of I-125 bound proteins	132.3	1	50.4	0.0035		1	0.0
South Weymouth	South Shore Hospital	Diagnostic nuclear medicine	100.0		0.0	0.0000		0	0.0
Stoughton	Biomedical Technologies, Inc.	Manufacture of Iodine-125 labeled compounds	29.0		0.0	0.0000		0	0.0
Stoughton	Goddard Memorial Hospital	Diagnostic nuclear medicine	10.0		0.0	0.0000		0	0.0
Walpole	Ciba Corning Diagnostics Corp.	Manufacture, R & D, of immunodiagnostic kits	1,917.6	10	30.7	0.4256	55 Gal. Drum	4	0.0
Wellesley	Wellesley College	Teaching and research	97.5	10	0.0	0.0000		0	37.5

1992 Inventory of LLRW Generators (continued)

City	Organization	Reason for Use of Radioactive Materials	Volume Produced (cubic feet)	Reported Treatment Code[1,2]	Volume Shipped (cubic feet)	Activity Shipped (curies)	Shipping Containers	Number of Shipments	Volume Stored On-Site
Westwood	Damon Clinical Laboratories, Inc.	In-vitro testing	1,075.4		0.0	0.0000		0	49.2
Westwood	PB Diagnostic Systems, Inc.	R&D of medical diagnostic products	32.5		30.0	0.0001	55 Gal. Drum	1	0.0
Plymouth County									
Brockton	Advacare Management Services	Medical diagnostic outpatient testing	223.5		0.0	0.0000		0	0.0
Brockton	Brockton Hospital	Diagnostic nuclear medicine	100.0		0.0	0.0000		0	0.0
Brockton	Cardinal Cushing General Hospital	Nuclear medicine	6.0		0.0	0.0000		0	0.0
Duxbury	Battelle Ocean Sciences	Primary productivity studies	10.1		8.0	0.0000	30 Gal. Drum	1	2.0
Plymouth	Bartlett Nuclear, Inc.	Mobile decontamination services	50.0		0.0	0.0000		0	7,000.0
Plymouth	Boston Edison Co.	Generation of electricity	33,084.6	4, 10	6,267.9	545.0561	EL-142, 14/215, 210 Poly HIC	34	445.7
Plymouth	Jordan Hospital	Clinical nuclear medicine	16.0		0.0	0.0000		0	0.0
Wareham	Springborn Laboratories, Inc.	Environmental fate and toxicology studies	367.5	10	112.5	0.0271	55 Gal. Drum	4	0.0
Suffolk County									
Boston	Angell Memorial Animal Hospital	Diagnosis and therapy of animals	80.0		0.0	0.0000		0	0.0
Boston	Beth Israel Hospital	Nuclear medicine, radiation therapy, endocrinology, clinical chemistry	1,969.9	10	60.0	0.0421	55 Gal. Drum	19	0.0

1992 Inventory of LLRW Generators (continued)

City	Organization	Reason for Use of Radioactive Materials	Volume Produced (cubic feet)	Reported Treatment Code[1,2]	Volume Shipped (cubic feet)	Activity Shipped (curies)	Shipping Containers	Number of Shipments	Volume Stored On-Site
Boston	Boston Biomedical Research Institute	Biomedical research	0.8		0.0	0.0000		0	0.0
Boston	Boston City Hospital	Nuclear medicine, research, clinical procedures	162.0	2	7.5	0.0015	55 Gal. Drum	12	0.0
Boston	Boston University	Teaching & research	268.8	3, 10	15.6	0.0184	55 Gal. Drum	4	0.0
Boston	Boston University Medical Ctr.	Medical research, patient care	835.1	2, 9, 10	104.7	0.2914	55 Gal. Drum	11	0.0
Boston	Brigham & Women's Hospital	Patient care, research, service	2,852.8	10	19.0	0.0485	55 Gal. Drum	4	0.0
Boston	Bunker Hill Community College	Teaching & research	15.0		0.0	0.0000		0	0.0
Boston	Center for Blood Research	Laboratory tracer studies	530.0	1, 10	5.0	0.0059	55 Gal. Drum	3	0.0
Boston	Children's Hospital	Medical research and diagnosis	1,744.0	10	17.0	0.0087	55 Gal. Drum	5	0.0
Boston	Dana-Farber Cancer Institute	Cancer research, diagnosis and therapy	2,345.8	10	7.3	0.0007	55 Gal. Drum	6	0.0
Boston	Du Pont Medical Products	Manufacture of radiopharmaceuticals	14,853.1	4, 10	3,804.9	43,352.5435	200 Liter HIC	19	4,785.0
Boston	Eye Research Institute of Retina Foundation	Biomedical research	72.0	10	0.0	0.0000		0	0.0
Boston	Forsyth Dental Center	Biomedical research	50.7		0.0	0.0000		0	0.0
Boston	Gillette Co., Toiletries Technology Laboratory	Radiotracer studies of toiletries products	1.2		0.0	0.0000		0	2.4
Boston	Harvard University	Medical R & D, teaching	4,489.9	1, 10	92.8	0.5046	55 Gal. Drum	16	0.0
Boston	Joslin Diabetes Center	Biomedical research & clinical Assays	744.5	1, 10	2.9	0.0060	55 Gal. Drum	2	0.0

1992 Inventory of LLRW Generators (continued)

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Boston	Life Signs/Group, Inc.	Clinical nuclear medicine	15.1		0.0	0.0000		0	0.0
Boston	MassachusettsCollege of Pharmacy	Teaching and research	4.0		0.0	0.0000		0	0.0
Boston	MassachusettsEye & Ear Infirmary	Medical R & D	235.2	10	1.1	0.0000	55 Gal. Drum	1	0.0
Boston	MassachusettsGeneral Hospital	Medical diagnosis and therapy R & D	4,686.3	1, 10	11.0	0.0008	55 Gal. Drum	3	0.0
Boston	Massachusetts, University of	Academic research	67.5		15.0	0.0065	55 Gal. Drum	1	0.0
Boston	New England Aquarium	Basic applied research	0.9		0.0	0.0000		0	2.1
Boston	New England Baptist Hospital	Diagnostic radionuclide scanning	12.0		0.0	0.0000		0	0.0
Boston	New England Deaconess Hospital	Medical research	763.2	1, 10	410.7	6.0873	5, 30, 55 Gal. Drum	13	0.0
Boston	New England Medical Center	Diagnostic and therapeutic medical applications, biomedical research	909.3	1, 10	188.7	0.0703	55 Gal. Drum	8	0.0
Boston	Nissin Molecular Biology Institute, Inc.	Reverse transcript assay	9.0	1	4.0	0.0020	Steel Drums	1	0.0
Boston	Northeastern University	Research and teaching	264.1	10	132.3	0.0570	30 Gal. Drum	6	0.0
Boston	Spaulding Rehabilitation Hospital	Clinical nuclear cardiology program	10.0		0.0	0.0000		0	0.0
Boston	St Elizabeth's Hospital	Clinical nuclear medicine and research	111.0	10	0.0	0.0000		0	0.0
Boston	Tufts University School of Medicine	Biomedical research and teaching	577.5	1, 10	199.1	0.5446	55 Gal. Drum	6	0.0

1992 Inventory of LLRW Generators (continued)

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Boston	U.S.D.A. Human Nutritional Research Center	Biomedical research	135.0	1, 10	45.8	0.0275	55 Gal. Drum	5	0.0
Boston	V A Medical Center, Boston	Clinical nuclear medicine and nuclear cardiology studies	87.6	1, 10	7.5	0.0008	55 Gal. Drum	1	22.5
Charlestown	Diacrin, Inc.	Biochemical research	60.0	1	0.0	0.0000		0	15.0
Dedham	American Red Cross Blood Services	Bone marrow trans-plantation screening, irradiation of blood products	216.5		0.0	0.0000		0	0.5
Dorchester	Carney Hospital	Clinical nuclear medicine	11.0		0.0	0.0000		0	0.0
Jamaica Plain	Faulkner Hospital	Nuclear medicine	7.5		0.0	0.0000		0	0.0
Worcester County									
Clinton	LFE Industrial Systems Corp.	Manufacture of industrial gauges	10.0		0.0	0.0000		0	0.0
Fitchburg	Burbank Hospital	Diagnostic nuclear medicine	111.7		0.0	0.0000		0	0.0
Fitchburg	Fitchburg State College	Positron annihilation spectroscopy	6.1		1.1	0.0050	8 Gal. Drum	1	5.0
Gardner	Henry Heywood Memorial Hospital	Nuclear medicine studies	7.5		0.0	0.0000		0	0.0
Leominster	Leominster Hospital	Diagnostic nuclear medicine	7.5		0.0	0.0000		0	0.0
Milford	Milford-Whitinsville Regional Hospital	Diagnostic nuclear medicine	7.5		0.0	0.0000		0	0.0
Milford	TSI Center for Diagnostic Products	Radioimmunoassay	71.6		0.0	0.0000		0	0.0

1992 Inventory of LLRW Generators (continued)

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Millbury	Wyman-Gordan Company	Measurement of liquid level and gas purity	15.7		15.7	0.0200	55 Gal. Drum	1	0.0
Shrewsbury	Biohybrid Technologies	Radioimmunoassay procedures	150.0		0.0	0.0000		0	0.0
Shrewsbury	Worcester Foundation for Experimental Biology	Biomedical R&D and teaching	633.5	10	22.5	0.2300	55 Gal. Drum	10	0.0
Southbridge	Harrington Memorial Hospital	Diagnostic nuclear medicine	16.0		0.0	0.0000		0	0.0
Worcester	Clark University	Research and teaching	7.6		0.0	0.0000		0	0.0
Worcester	College of the Holy Cross	Teaching and research	23.3	9, 10	15.0	0.0004	55 Gal. Drum	1	0.0
Worcester	Genica Pharmaceuticals Co.	Enzyme Assays	3.0	10	1.5	0.0010		0	0.0
Worcester	Hybridon	Biomedical R & D	26.0		0.0	0.0000		0	0.0
Worcester	Institute of Molecular Biology	BiotechnologyR & D	157.7	1, 10	45.0	0.0227	55 Gal. Drum	9	0.0
Worcester	Massachusetts,University of (Medical Center)	Patient diagnosis and treatment, biomedical research	3,467.5	10	15.0	3.9000	55 Gal. Drum	3	83.5
Worcester	Medical Center of Central MA	Patient diagnosis	17.0		0.0	0.0000		0	0.0
Worcester	Medical Center of Central MA (Hahneman)	Clinical nuclear medicine	12.0		0.0	0.0000		0	0.0
Worcester	St Vincent Hospital	Medical usage	17.0		0.0	0.0000		0	0.0
Worcester	Telesector Resources Group	Replacement of cathode electron tubes in telephone switching equip.	164.7		10.7	0.0012	55 Gal. Drum	2	0.0

1992 Inventory of LLRW Generators (continued)

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Worcester	TSI Mason Research Institute	RIA procedures, tissue distribution, blood clearance studies	180.8	2, 10	16.7	0.0002	30, 55 Gal. Drum	2	201.5
Worcester	Worcester Polytechnic Institute	Teaching and research	8.0		4.0	0.0200	30 Gal. Drum	1	0.0
Total			349,392.2		119,004.2	76,362.7		612	31,711.2

[1] Treatment at out-of-state facilities.
[2] Treatment Code Legend: 1-Compaction up to 250 Tons, 2=Compaction 251-999 Tons, 3=Compaction 1000-2500 Tons, 4=Compaction above 2500 Tons, 5=Storage for Decay, 9=Solidification, 10=Incineration, 11=Size Reduction\Sectioning, 12=Adsorption, 14=Absorption, 18=Dry Chemical Packing.

Source: MassachusettsLow-Level Radioactive Waste Management Board.

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